Manual 4
Baking and cooling of biscuits

What happens in a baking oven
Types of oven
Post-oven processing
Cooling
Handling
Troubleshooting tips

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Manual 4

Baking and cooling of biscuits

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Manual 6
Biscuit packaging and storage
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Preface

My text *Technology of Biscuits, Crackers and Cookies*, which was first published in 1983, with an enlarged new edition in 1991, has proved very successful and been welcomed by biscuit manufacturers worldwide. Why, then, consider producing separate manuals in the same field?

The idea started, I suppose, when my partner, Pam Chance, pointed out that, as a standard reference work, my book was both too detailed and expensive for the average plant operative to use in the course of his or her work.

Over the years, I have worked as a consultant in very many factories in many countries. Not all the operatives speak English, but those that do have explained that they often do not know the biscuit technology with which they are involved nor have a convenient source of information. They and their managers have particularly expressed the need for aids to troubleshooting.

Thus this manual was born. It is one of a sequence that covers the various parts of the biscuit-making and packaging process. It builds on *Technology of Biscuits, Crackers and Cookies*, but includes much new material. I have tried to give particular emphasis to process mechanisms and fault solving. I am sure that managers, trainers and operatives will find it useful both in training and as a reference source.

I hope that all who read and use it will find it as useful as I would like it to be. If you have any comments or contributions, I should be pleased to hear from you.

Duncan J R Manley
1998

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1 Introduction

This manual is one of a series dealing with materials and manufacturing procedures for biscuits.

It describes, in general terms, what is involved in baking and cooling biscuits from dough pieces that have been placed on the oven band. The baked biscuits are either packed or sent for secondary processing. Secondary processing includes cream sandwiching, chocolate coating, icing, etc. The process of making dough pieces is dealt with in Manual 3, *Biscuit dough piece forming*, packaging is covered in Manual 6, *Biscuit packaging and storage* and secondary processing is covered in Manual 5, *Secondary processing in biscuit manufacturing*.

If you are a member of a manufacturing team you should know how to do your tasks and the **reasons** for doing things in a specified way. You should also understand the possible implications of not doing a task correctly or not communicating difficulties promptly. The processes involved in baking biscuits are described. The critical aspects to watch for during the various stages of baking and post oven operations are also described. It is essential for the efficient running of the factory and the production of biscuits of correct size, colour and moisture content that the biscuits are baked correctly. When biscuits emerge from the oven is the first time that they can be assessed for suitability for packaging or for passing on to secondary processing. Faults noticed and action taken by the baker (the operator responsible for controlling the oven) can make a significant contribution to the efficiency of the biscuit manufacturing process.

From time to time problems will arise. A competent operator will be able to recognise and correct faults quickly. Sections are included in this manual which describe common faults and problems and should therefore aid troubleshooting and problem solving.

If you work in a food factory you must accept some responsibilities. These, to a greater or lesser extent, will include:

1 Responsibility for the quality of the company's products if you are a member of a production team. By critical observation and knowing what to look for and expect, you could prevent a fault occurring in manufacturing.
2 Responsibility for the safety of consumers who will eat the products you help to make and pack. The procedures and precautions you should observe are described.
3 Responsibility for the machines and equipment with which you are required to work. The procedures and precautions you should observe are described.

1.1 Vocational qualifications

The approach to training in industry is changing. Instead of a reliance on knowledge, which has typically been assessed by set piece examinations, there is now a focus on competence which is assessed in the workplace. This means that a worker must not only know what he or she should be doing but also has to demonstrate that he or she can do it!

Typically, set piece examinations require the examinee to achieve a 'pass' mark which may be as low as 40%. This accepts the fact that by no means all of the subject matter is known well enough for the examinee to pass the examination. Under the competence system, to qualify, the worker must satisfy the examiner, usually known as the assessor, in **all** matters. The worker must demonstrate knowledge, ability and communication skills as required for the level of the qualification being assessed. These qualifications are known as vocational qualifications (VQs).

There should be VQs for all employees from the newest and youngest to the most senior. Through training, workers may progress to higher and higher levels. In the developing British system there is a framework of five levels which can be described as:

- **Level 1** – Competence in the performance of a range of varied work activities, most of which may be routine and predictable.
- **Level 2** – Competence in a significant range of varied work activities, performed in a variety of contexts. Some of the activities are complex or non-routine, and there is some individual responsibility or autonomy. Collaboration with others, perhaps through membership of a work group or team, may often be a requirement.

- **Level 3** – Competence in a broad range of varied work activities performed in a wide variety of contexts most of which are complex and non-routine. Often considerable responsibility and autonomy, and control or guidance of others is required.
- **Level 4** – Competence in a broad range of complex, technical or professional work activities performed in a wide variety of contexts and with a substantial degree of personal responsibility and autonomy. Responsibility for others is often present.
- **Level 5** – Competence which involves the application of a significant range of fundamental principles and complex techniques across a wide and often unpredictable variety of contexts. Substantial personal autonomy and often significant responsibility for the work of others and for the allocation of substantial resources feature strongly, as do accountabilities for analysis and diagnosis, design, planning, execution and evaluation.

It should be possible to categorise all jobs within a company in one of these five levels. To achieve accreditation at any level it is necessary to satisfy the assessor in a defined number of **units** (each of which has a number of **elements**). There are some mandatory (core) units and some optional units, a defined number of which must be selected, for each level. This reflects the fact that workers at a given level may have jobs that are biased towards production or production support and may be more technical or supervisory. In many respects there will be overlaps between levels and the greatest difficulty tends to arise between levels 3 and 4. The flavour of level 3 should be 'optimise, prioritise and improve' and of level 4 'plan, initiate, develop and manage'.

Thus, it can be seen that as the level of competence progresses there is a change from understanding, to seeking ways of improving and helping the business to become more efficient.

For all jobs and tasks there is a need to define What, Why and How? In biscuit making there are technical aspects which include, what are the ingredients, products, processes and machines, why particular ingredients, packaging materials and processes are needed for different products and how machinery is controlled and maintained. Technical knowledge and skills are needed for problem solving, and to ensure good hygiene and safety in the workplace. Communication skills are also needed which include reporting to and supervising others.

Competence cannot be achieved only from a book but reading and

thinking are an aid to learning about ingredients, processes and machinery and understanding what variations may occur. Thus, a book can provide essential underpinning knowledge and is a source of reference when something new or unusual happens.

Using this manual will help you to become a competent employee involved in biscuit manufacturing. The underpinning knowledge with respect to successful baking of biscuits that is contained here is relevant particularly to most of the technical aspects of levels 2 and 3, as defined above.

2 Background to the biscuit industry

2.1 What are biscuits?

Biscuits are small baked products made principally from flour, sugar and fat. They typically have a moisture content of less than 4% and when packaged in moistureproof containers have a long shelf life, perhaps six months or more. The appeal to consumers is determined by the appearance and eating qualities. For example, consumers do not like broken biscuits nor ones that have been over or under baked.

Biscuits are made in many shapes and sizes and after baking they may be coated with chocolate, sandwiched with a fat-based filling or have other pleasantly flavoured additions.

2.2 How are biscuits made?

Biscuits are a traditional type of flour confectionery which were, and can still, be made and baked in a domestic kitchen. Now they are made mostly in factories on large production plants. These plants are large and complex and involve considerable mechanical sophistication. Forming, baking and packaging are largely continuous operations but metering ingredients and dough mixing are typically done in batches.

There is a high degree of mechanisation in the biscuit industry but at present there are very few completely automatic production plants. This means that there is a high degree of dependence on the operators to start and control production plants. It is essential that operators are skilled in the tasks they have to do and this involves responsibility for product quality. As part of their training they must know about the ingredients and their roles in making biscuits. They must be aware of the potential ingredient quality variations and the significance of these.

There are basically two types of biscuit dough, hard and soft. The difference is determined by the amount of water required to make a

dough which has satisfactory handling quality for making dough pieces for baking.

Hard dough has high water and relatively low fat (and sugar) contents. The dough is tough and extensible (it can be pulled out without immediately breaking), like tight bread dough. The biscuits are either crackers or in a group known as semi-sweet or hard sweet.

Soft doughs contain much less water and relatively high levels of fat and sugar. The dough is short, (breaks when it is pulled out) which means that it exhibits very low extensible character. It may be so soft that it is pourable. The biscuits are of the soft eating types which are often referred to as 'cookies'. There are a great number of biscuit types made from soft doughs and a wide variety of ingredients may be used.

The machinery used to make biscuits is designed to suit the type of dough needed and to develop the structure and shape of the individual biscuits.

Secondary processing, which is done after the biscuit has been baked, and packaging biscuits are specific to the product concerned. There is normally a limited range of biscuit types that can be made by a given set of plant machinery.

Many biscuit production plants bake at the rate of 1000–2000 kg per hour and higher rates are not unusual. Given this and the sophistication of the production line it is most economical to make only one biscuit type for a whole day or at least an eight hour shift. Start-ups and changeovers are relatively inefficient.

2.3 How a factory is arranged

Typically the factory is long and, for the most part, normally on only one floor. The reason for the length is principally due to the oven.

Tunnel ovens have baking bands that are usually between 800–1400 mm (31–55 in) in width. The length of the oven determines the output capacity of the plant. Ovens have been made up to 150 m in length but 60 m (about 200 feet) is probably the average length.

Ideally, and normally, the ingredients are stored and handled at one end of the factory. Next to the ingredients store is the mixing area and next to that are the continuous production plants. The baking plants feed cooling conveyors, which are often multitiered to save space, and the baked and cooled biscuits are then packed using high speed machines.

In some factories secondary processes are involved after baking. It

is also possible that only semi-automatic packaging is used which requires manual feeding of the wrapping machines. In these cases biscuits may be taken from the baking line and placed temporarily in boxes or stored in other ways. These activities are typically labour intensive.

2.4 What your company requires from the factory

Your company exists to make a profit! The means of earning this profit is by making and selling biscuits (and possibly other products).

The products that are made are designed to meet current market needs and to this end they have specifications in terms of pack size, biscuit eating qualities and appearance and ingredient types and quantities. These specifications define limits and it is the task of the production department to ensure that only biscuits which meet the specifications are packed and sold. All substandard product must be disposed of through other routes and will represent a financial loss to the company.

The production cost of a product is a combination of ingredient and packaging material costs, labour (which involves the production time), fuel for the machines and baking, and overheads which include management, maintenance and other support services. A significant cost is the labour associated with the production time. The efficiency of production, which is measured by the quantity of saleable product produced in a specified time, is an important aspect of the product cost.

The duty of the Production Department to the company is to produce a minimum of scrap product and have a minimum of production downtime. Both of these requirements are influenced strongly by the skills and performance of the plant operators.

2.5 Biscuit baking areas

Biscuit baking is normally achieved in a tunnel oven through which a continuous baking band is passing. Dough pieces are placed onto the baking band and baking takes place during, typically, the following 2.5–15 min.

Heat is applied to the dough pieces in a variety of ways. The amount of heat and the removal of steam and other products of combustion and baking are controlled, either at places along the length of the oven or from a control panel near the exit from the oven.

It is not possible to watch the changes that happen during baking although a few inspection doors may be provided along the length of the oven. Therefore the baker must visualise what is happening in the oven and make adjustments to the oven controls to bring about a satisfactorily baked biscuit.

Instrumentation of ovens is typically rather basic. The speed of the baking band can be controlled and the faster the band the greater will be the production rate but the less time there will be for the oven to heat the dough pieces. Heat causes a development of open texture, coloration and drying in the biscuits. There may be thermometers to indicate temperatures in a few places within the oven chamber but these may not reflect accurately the conditions being experienced by the dough pieces on the baking band. Other temperature probes will be used to control the power from the burners used to heat the oven. There are levers to adjust the movement of air within the oven and also the amount of air that is taken from the oven and passed out from the extraction ducts. These levers will be calibrated but there is no indication of what exactly are the conditions within the oven.

Each product may require different baking conditions and each oven has performance differences from other ovens even though they are apparently identical.

As the biscuits come out of the oven they are hot and may be soft. Provision is made to allow some cooling and then removal from the baking band without distortion of the biscuit shape or structure. Immediately after baking the biscuits may be cut or sprayed with oil, etc. before passing onto conveyors where they are allowed to cool before packaging or passing for secondary processing.

2.6 Your contribution when baking biscuits

The most important contribution you can make to the efficiency of the factory when baking biscuits is to ensure the following:

- Understand the critical points to watch for in the quality of biscuits as they emerge from the oven.
- Know how to set the oven at start up and how long to wait before production can commence.
- Know how to alter the heat and other oven conditions in response to measurable qualities of the biscuits being baked.
- Record continually the results of measurements made on biscuits and communicate occurrences of substandard product to the

subsequent process operators, that is, those in charge of packaging or secondary processing.

- Maintain good communication with the dough piece forming operator so that you know when production starts, when there are breaks in production or when adjustments are needed to the dough piece weight as a result of measurements made on baked biscuits.
- Try to ensure that a minimum of over- or underbaked biscuits are produced as these represent inefficiencies in production and therefore loss of profits.
- Know what to do in the event of the oven band stopping unexpectedly as, for example, a result of an electric power failure. Quick and correct action is needed to prevent fires which damage conveyors, etc.
- Look out for machinery that requires maintenance for reasons of oil leakage, malfunction or wear on the baking band and report the problem without delay to your supervisor.
- Avoid straining yourself; do not try to move heavy weights without help or using the appropriate machinery.

It is not unusual to find faults or to have queries. You must communicate.

It is essential that if you are in doubt you should not hesitate to ask, even if you know that you should know the answer!

3 Hygiene and safety aspects

The regulations relating to food production are continually being tightened with the aim of improving the safety of food products and the safety of people working in food factories.

If you work in a food factory you must be acquainted with the potential dangers and constantly endeavour to prevent the food becoming contaminated with noxious substances. You must also make sure that your actions do not put yourself or your colleagues at risk of injury.

3.1 Safety of food products

Biscuits will be unfit or unpleasant to eat if they are contaminated in the course of their manufacture and packaging. Contamination means that unwanted material becomes included in or on them. Some forms of contamination may be positively dangerous to the health of those who eat the biscuits.

It is therefore important that the problem of contamination is considered because it is the basis of food hygiene which is the responsibility of all who work with food.

It is not possible to list all the possible hazards to hygiene that may be encountered in a biscuit factory but the following section should help to make you aware of the likely problem areas.

3.2 Sources of contamination

3.2.1 People

- Contamination may come from people via the microorganisms on their hands. Hairs, buttons and pieces of jewellery may fall from their bodies and clothes and articles may fall from pockets.
- The most important requirement is that all those who handle, or are likely to handle food, is to observe basic rules of personal

hygiene. Disease is quickly spread if food handlers are negligent about hand washing following visits to toilets. It is very unpleasant to have food contaminated with grease or other dirt from unwashed hands.

- At all food premises good, clean washing facilities must be provided with continuous supplies of hot and cold water, non-scented soap and disposable towels. Cold water with no soap and communal towels are not adequate.
- Hand washing sinks and facilities must be separate from those used to wash equipment.
- **All food handlers must ensure that their hands are washed and clean before handling food and it is particularly important that their hands are washed after each visit to the toilet.**
- Employers must provide clean overalls and hair coverings for all personnel. These are to be worn only in the food factory. No personal food, drink containers, loose money, pins, jewellery (other than plain wedding rings), watches, radios, books, newspapers and smoking tackle should be allowed into the production areas. Hair brushing or combing necessitating removal of head gear should be forbidden in production areas. **In this way the possibility of contamination by loose articles is significantly reduced.**
- Smoking involves the hands becoming contaminated with saliva and the by-products – matches, ash and cigarette ends, are particularly repulsive. **No smoking should ever be allowed in the production areas.**
- Operators who have cuts, abrasions or skin infections, particularly on the hands or arms, should be especially careful. **Bandages or dressings should be of good quality and be, at least partly, brightly coloured and easily detectable should they be lost.**

In those premises where metal detectors are available for product scanning, it is additionally useful for the bandages to contain metal strips that will be found automatically should a bandage be lost in the product.

- **Food handlers suffering from intestinal complaints** such as diarrhoea or other contagious diseases **should be required to keep away from production areas** until they recover.
- It is frequently necessary for operators to carry certain small articles with them in the course of their duties. **Articles such as**

pens, pencils, gauges and various tools should not be carried in top pockets in case, while bending over, they should fall into the product or machines. Overalls provided with no top pockets remove this possibility!

- Where gloves are needed either of fabric type (as for chocolate handling) or waterproof, they require regular washing and drying both inside and out. **Gloves should not be used by more than one person and they should be replaced when damaged.**

3.2.2 Emptying containers

- When bags or boxes are opened and emptied there is a great potential for contamination.
- Pieces of string or paper removed in the opening process must be placed in rubbish bins and not on the floor.
- Before inverting a bag, box or other type of container, ensure that it has not collected floor or surface dirt that could fall into an unwanted place.
- Dispose of the empty container in a responsible way so that spillage or dust is avoided as much as possible and it is not a danger to other workers.

3.2.3 Small items of equipment

- In most biscuit factories it is necessary to use bowls, beakers or trays to carry and weigh ingredients or dough. These should be made of metal or plastic because glass is particularly dangerous, making splinters or small fragments if broken.
- **Glass containers must never be taken into production areas.** Where ingredients are delivered in glass containers they should be dispensed into non-breakable containers in specially designated rooms away from the production areas.
- Colour coding of containers is better than labels which may fall off. Elastic bands provide a particular hazard due to their tendency to fly off in unexpected directions and become lost.
- All utensils should be stored, full or empty, on special clean stillage so that they are off the floor. This is to ensure that when inverted no floor dirt can fall from them on to product or into a mixer.
- After use all containers should be washed in hot water, with detergent as necessary, and left inverted to dry.

- Cleaning equipment such as cloths, brushes, mops and scrapers should be stored and dried after use on specially provided racks, hooks or rails, off the floor.
- Detergents used for cleaning equipment must be of approved types and stocks must be stored separately away from ingredients or dough containers.
- Office equipment such as elastic bands, paper clips and particularly pins should be forbidden in the factory environment.

3.2.4 Plant machinery

- At the end of each production run all machines should be cleaned immediately so that buildup of dough or other materials does not become hard, or mouldy and an attraction for insects.
- As a basic principle, all food machinery should be mounted off the floor so that the floor can be thoroughly swept or washed at regular intervals.
- Covers for the moving parts of machinery should be properly fixed at all times and kept in good repair. All surfaces should be wiped down regularly and washed with warm water and detergent if necessary.
- Fabric conveyors should be checked regularly to watch for frayed edges or seams. If necessary these should be trimmed with a sharp knife or the conveyor replaced.
- If a machine is not to be used for some time it should be covered with a dust sheet.
- Drip trays and other catch containers must be emptied and cleaned regularly, but certainly at the end of each production run.
- Particular care should be taken that mineral lubricating oils and greases do not contaminate food. Leaking motors, gearboxes or bearings should be reported without delay for engineering maintenance.
- Where it is necessary to climb up to high parts of machines or where ladders are needed to get over machines, special walkways with adequate guarding should be provided to prevent floor dirt, carried on footwear, dropping on to dough, products or food surfaces.
- No string should ever be used to attach wires or other articles in production areas and fibrous or loose insulation materials should be covered and fixed securely to prevent disintegration.
- Nowhere in production areas should wood be used. This is easily splintered and pieces find their way into ingredients or dough.

- As machinery is replaced or becomes obsolete it should be completely removed from the production area and stored (preferably in a reasonably clean condition) in a store remote from the factory. In many factories the machinery graveyard is an ideal home for marauding rats, mice and insects. It is ideal from their point of view because it is dry and undisturbed. Food can be taken there and breeding take place in relative comfort! The convenience of such a home should be denied within the production environment.

3.2.5 Buildings and general factory areas

A major source of contamination is from insects, animals and birds. Also dirt or loose particles falling from overhead areas offer potential hazards.

- Flying insects and birds must be excluded from the factory by using screens over ventilation fans and windows which open.
- Open doorways should have plastic strip or air curtains to prevent entry of insects and birds.
- Doors to the outside should fit closely to the floor so that animals cannot enter at night or other times.
- Rodent control systems should be regularly maintained and any bait must be placed only in specially designed and sited containers which are clearly marked. Damaged bait containers should be disposed of immediately and safely.
- Trunking for wiring and other services should be well sealed to reduce the chance of dust accumulation followed by insect infestation.
- High ledges and roof supports where dust can collect should be of sloping construction and be cleaned regularly.
- Good lighting should be maintained in all production areas and plastic screening, where appropriate, be used to prevent glass falling on to the product should light bulbs or tubes be broken.

It is a requirement that all food workers are aware of these potentials for contamination and that they report to management without delay, any aspects that do not seem satisfactory.

3.3 Safety of people

Your employer is required to ensure that the areas in which employees work and the machinery they use is safe. However, if employees are negligent in reporting faults or in cleaning operations, etc. it is possible that an otherwise safe situation can become unsafe. You should therefore be aware of where unsafe situations may arise which could affect you or your colleagues.

3.3.1 Floors

Dirty floors which have become wet or greasy are slippery. Clean up as necessary.

3.3.2 Machine guards

Moving parts especially those where a nip is involved must be guarded to prevent hands or clothing becoming trapped. It is particularly dangerous to run a machine with these guards removed. Experience shows that accidents involving machines occur more often to 'experienced' operatives. They become overconfident and try to overcome problems by running machines with guards removed.

3.3.3 Electrical connections

Most machinery is driven and controlled by electricity. For safety and other reasons the connections and other electronic components are housed in cabinets or under guards. The danger of electricity cannot be seen so it is very dangerous to remove guards. Faults with electrical apparatus must be reported to management or responsible engineers.

3.3.4 Strain injuries

Back strain is a very common injury experienced by factory workers. It is unpleasant for the person who receives it and a potential cost to the employer due to the need for sickness leave.

Back strain derives from physical effort done incorrectly or carelessly. Think when moving and lifting bags, boxes or pieces of machinery. If they are too heavy get help. If the floor is slippery take

extra care. Do not try to lift something too high without help. Do not expect a colleague to help you if he or she is not clear what is expected or is not strong enough to do it.

3.3.5 Dust

Dirt is defined as material in the wrong place! Dust soon becomes dirt. It is unpleasant and may be dangerous to breath and it may accumulate and fall into containers bearing food or ingredients. Make sure that your actions cause as little dust as possible and clean up after you.

3.3.6 Building maintenance

When repairs and decoration are being done it is essential that nearby production equipment is covered with sheets so that particles of metal, glass, masonry and paint do not fall into places where they could later be included with dough or product. A magnet provides a useful means of collecting most metal particles.

4 Problem solving

4.1 Introduction

Biscuits are usually baked in vast numbers in continuously running ovens. It is necessary to maintain a constant vigilance to ensure that the biscuits are made with minimum variation. If this is not done, or is done badly, biscuits may be made that are not suitable for consumption, that will not fit into the packaging or do not match the quality requirements for your company. From time to time it is necessary to make adjustments and alterations to the process to maintain the biscuits within specification. It is the duty of plant operators to make these adjustments. The efficiency of a factory is largely measured by the skill of operators in making these adjustments correctly, accurately and speedily.

In most cases problems are not caused by one factor alone. They are the result of interactions between several factors including ingredients, machine settings and other processing conditions. This means that check lists for both identifying and solving problems are often not simple. Ideally it would be good to have an interactive problem solving computer program that would interrogate the operator(s) and offer a set of instructions that would lead to the removal of the problem. As far as is known such a computer program has not yet been developed. Not all factories have computers available on the factory floor. Where computers are not available, it is suggested that **reference charts and lists** are kept as a back up to experience and memory of what happened previously. Having observed a problem, the chart or list can be used as a guide to further action. However, understanding why a fault or problem may have arisen is better assessed with some background knowledge. Reference lists are located in Section 8, *Process control of baking and troubleshooting*.

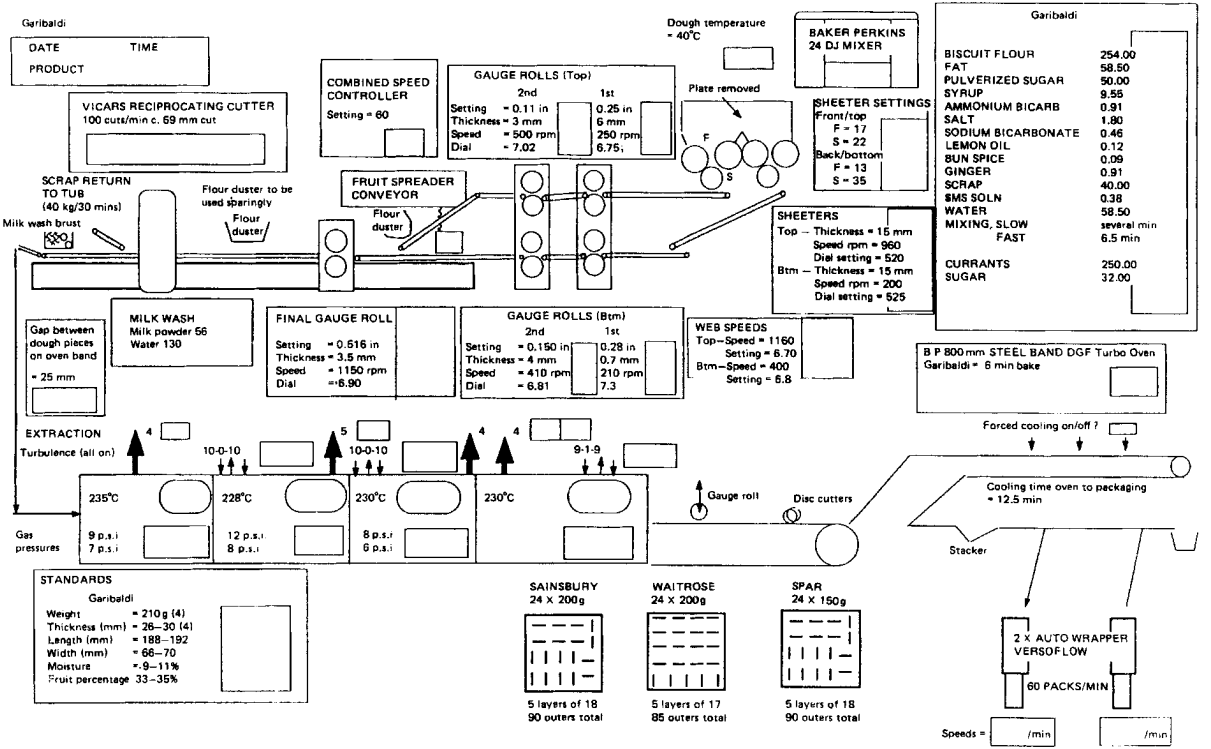


Fig. 1 Process audit record for production of Garibaldi biscuits.

4.2 The Process Audit Record

Much difficulty is encountered at plant start up. A slow start is inefficient and can be costly to the factory. There is therefore a need to set the plant so that the start up is as smooth as possible. Drawing on previous experience is clearly the best approach and to this end a **process audit record** (see Fig. 1) should be available for each plant for each biscuit that is made. It will give details of machine settings and speeds and the values of process measurements that have to be taken. From time to time the validity of the information on the process audit record will be checked and reviewed because processes can change as a result of time of year and quality of ingredients, etc.

4.3 Control philosophy

When faults and difficulties occur it is necessary to determine their cause and to act as quickly as possible to cure them. The aim in this manual is to enable quick fixes, not detailed research programmes that will take a long time and lead to significant changes in processing methods. It is assumed that production of the products in question has proceeded well for long periods but problems have arisen, which if not attended to, will cause inefficiency or waste.

First, the nature of the fault or problem must be identified. If a pattern in the occurrence of the fault can be found, its cause, and thence its remedy, is more likely to be found. The nature of the patterns of faults and problems will be discussed as appropriate. A common pattern relates to the length of time taken for a batch of dough to be used.

If the control philosophy is wrong the order of making adjustments will not solve the problems that are encountered satisfactorily. Although this manual relates to baking it will be appreciated that this part of the biscuit making process cannot be viewed in isolation. Therefore, an overall statement of control philosophy follows.

Control implies adherence to product specifications and production targets. The data on the process audit chart will show details on a single occasion when the plant was running well, of the whole plant and process, not just the baking in isolation. It will therefore be a useful reference point if difficulties are encountered.

To maintain a plant in control the following principles should be

observed:

- Make measurements but only where and when required.
- Relate sampling and measurements to subsequent processing requirements.
- Consider the significance of the results of measurements with respect to those that can reasonably be achieved with the instruments being used. For example, if the reproducibility of a test is poor then small differences in measurements may not mean that changes are occurring.
- Relate measurements to targets which have specified limits.
- Try to understand what affects the parameter being measured and therefore what type of action can be taken when necessary.
- Concentrate process control surveillance on baked biscuits at the oven exit.
- Biscuit weight is the primary parameter. Changes in weight will probably result in changes in other measurable characteristics like size and colour so concentrate on controlling weight before other characteristics.
- Concentrate process control surveillance in those places where significant variation is known to occur or can be expected.
- Record **all** measurements against time preferably on a chart which allows easy view of changes and trends.

The basic measuring tools applicable to baking are:

- a balance for weighing biscuits,
- a length gauge for checking thicknesses and biscuit sizes,
- an instrument or reference samples for checking biscuit baked colour,
- an instrument for checking biscuit moisture content,
- a clock telling the time of day.

5 Types of oven and baking bands

5.1 Introduction

There are many different oven designs and progress is constantly being made. It is not possible to give an exhaustive summary of how all types of oven work or are controlled because of the engineering detail that would be required. Most biscuits are baked in a tunnel oven in a continuous process but there are some cases where a static oven is used and trays of dough pieces are put into the oven and removed after a suitable interval. Static ovens will not be considered here even though they are the type usually employed in test bakeries.

Typically biscuits are baked in long tunnel ovens. The ovens are made up of a number of independently heated and controlled zones. The shortest ovens may have only one zone but longer ovens have two or many more zones. A typical configuration consists of three or four zones. The provision of zones allows different temperatures, heat applications and extraction conditions to be provided as the dough pieces are baked into biscuits.

The production rate of an oven is defined by its length and the baking time needed to bake a product to the desired structure, colour and moisture content.

It is not easy to measure heat compared with the ease with which temperature is measured. In the early ovens a lining of refractory bricks permitted considerable storage of heat which helped to reduce changes in oven air temperatures when passage of product was intermittent. However, it takes some time to heat these bricks when the oven is started and a long time to cool them at shut down. Thus, there is considerable inertia if the product requires a higher or lower heat input. The important feature, however, is that a considerable amount of heat can be transferred to the product by radiation and some feel that this is the best method of baking.

To overcome many of the inconveniences of the brick lined ovens there has been a general move towards lightweight oven structures

insulated with rock wool or fibre glass. To enhance heat exchange, turbulence is used and this introduces the need to achieve uniform and controllable air movement within the oven.

Provision is always made to vary the ratio of heat that can be supplied to the top and bottom of the product.

Biscuit ovens are available to suit the type of fuel to be burnt (gases and oils, of varying qualities, or electricity) and to dissipate this heat either directly or indirectly into the oven chamber. Fuels for ovens are all becoming relatively more expensive and although the cost of fuel is a small proportion of the total production cost of biscuits, there is nevertheless a growing concern to improve oven efficiency and to use less fuel.

Extraction of the oven atmosphere is via ducts and flue pipes that take the gases out through the roof of the factory. Extraction may be natural or aided with fans. The latter is to be preferred as natural extraction is much affected by the wind speeds and temperatures outside the building. The amount of extraction is controlled by a slide valve in the flue pipe, usually before the extraction fan.

Ovens of all types tend to have a large number of control points offering a bewildering range of possibilities. In many cases problems are increased because the controls are only crudely calibrated and are located along the length of the oven.

The product is taken through the oven on a continuous band (rarely the oven band is a chain that takes trays). Through the oven the band is supported on metal skids or rollers spaced sufficiently close to one another to prevent appreciable sagging of the band between them.

After passing through the oven the band returns under the oven usually outside the hot chamber. In this position it can be cleaned with wire or fabric rotating brushes.

In some cases provision is made for treating the band or its surface immediately before the dough pieces are panned onto it. These include preheaters, oiling sprays or rollers and flour dusters.

5.2 Direct fired ovens

In direct fired ovens the heaters are inside the baking chamber and are arranged above and below the baking band. The products of combustion (mostly carbon dioxide and water) come into contact with the dough pieces so only clean gas (or electric) heaters can be used in direct fired ovens. There can be an appreciable buildup of

'humidity' from combustion of the gas. As there is a significant amount of radiant heat from each burner/heater there are usually a large number of individual burners to provide a more or less even heat application as the biscuits pass through the zone. More heat is required at the front of the oven than at the back. Because the oven band and the dough pieces have to be heated quickly, there are usually more burners in the first zone than later ones. The heat is controlled either by varying the amount of gas being supplied to each burner or by turning off selected burners. The gas and air mixture supplied to each burner is made by pressurising either the gas or the air and blowing it through a venturi tube to make a suitable gas and air mixture.

There are usually control systems on all or a number of the burners to allow variable disposition of heat across the oven band. Adjustment of these is usually the engineer's, not the operator's, task.

The control system also incorporates safety systems so that the burners cannot be lit while there is a mixture of gas and air in the baking chamber and a complete shut down of the fuel system occurs if the oven band stops. Control of the oven temperature is via thermocouples sited within the baking chamber which modify the amount of gas passed to each burner.

Sometimes there is also provision for increasing the turbulence of the oven atmosphere to improve the heat transfer. This must be limited otherwise the flames on the burners may be extinguished. In order to achieve the benefits of good turbulence and thus good heat transfer by convection, some direct fired ovens have a single large burner per oven zone and the hot gases circulate through the oven chamber and back to the burner. These resemble, in design, indirect fired ovens, described below, in which the products of combustion do not pass into the baking chamber.

Direct fired ovens are the most powerful in terms of heat transfer. There may also be preheaters under the front of the oven to heat the oven band before dough deposition.

Figure 2 shows a typical design of a direct gas fired oven.

Electric ovens are a special case of direct fired ovens. Heater elements are arranged like the gas burners, above and below the band and either each is controllable or groups are controlled. Electric ovens are easy to start and stop and are the easiest type of oven to control. The extraction requirement is much less, with economy considerations, since there are no products of combustion but the

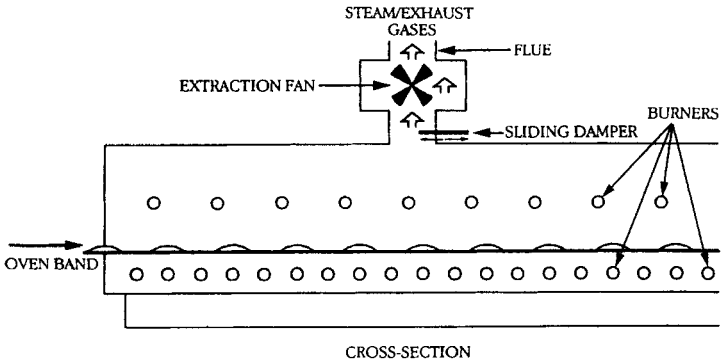


Fig. 2 A typical design of a direct gas fired oven.

oven 'humidity' is derived only from moisture lost by the product being baked.

Sadly, electricity is an expensive fuel in most countries so electric ovens are not universally common. However other more creative methods of using electricity for baking are being developed. These include special high powered radiant heaters for controlling surface colouring precisely and microwave and dielectric heating systems that do not colour but allow improved moisture removal and heat the centre parts of the dough piece. The use of electricity is mentioned again in Section 5.4.

5.3 Indirect fired ovens

Indirect fired ovens are so called because the products of combustion do not enter the baking chamber. There has to be a heat exchanger system to heat the oven atmosphere. Indirect fired ovens usually have one large burner per zone and this may be fuelled either by oil or gas. Either the hot gases from the burner are circulated through ducts which are in the baking chamber (and therefore radiate heat) or air from the baking chamber is circulated over a large heat exchanger near to the burner. Whichever is the system, dampers are provided to control and divert the passage of the hot gases to various parts of the oven chamber or up flues to the atmosphere. Flues must be provided for the products of combustion and for ventilating the baking chamber. The flue from the burner is not normally capable of restriction.

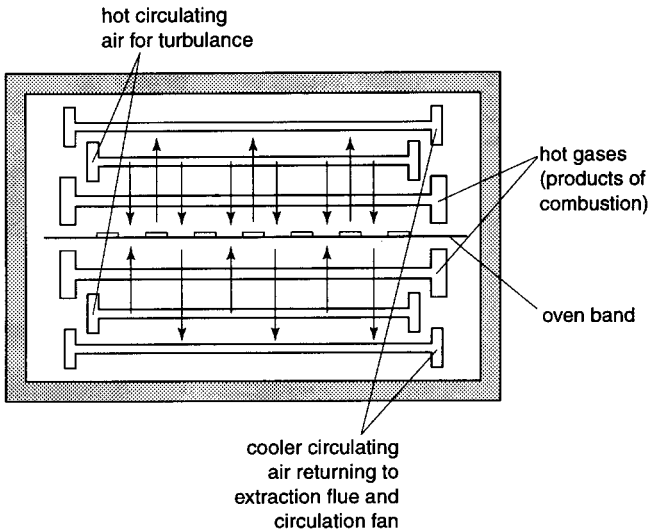


Fig. 3 One zone of an indirect fire oven.

Indirect fired ovens offer the design engineer flexibility in providing more or less radiant heating from hot tubes, and more or less convected heating by air circulation. The methods of heating can be different in successive zones of a tunnel oven.

Figure 3 shows a schematic design of one zone of an indirect fire oven.

5.4 Hybrid ovens

The number of independently controlled zones and the length of these zones should ideally be designed to suit the product being baked. It is possible therefore to have ovens composed of direct and indirectly fired sections. These are called hybrid ovens.

There is not enough power available in indirect fired ovens to bake most laminated crackers but the strong convection heating systems of indirect fired ovens suits moisture removal in the later sections of all ovens. Hybrid ovens therefore normally have one or two direct fired zones followed by indirectly fired zones.

The selective use of electric power may also be a feature of hybrid ovens with microwave power used along with another type of power. The use of dielectric power is usually in a unit after the oven, as will be explained in Section 7.

5.5 Types of oven bands

Oven bands are generally available in 800 mm, 1000 mm and 1200 mm widths, although other sizes can also be obtained. There are various types of band which offer varying degrees of openness, weight and usage life. Sheet steel bands may be 1.2 mm or 1.3 mm in thickness and weigh about 9 kg per square metre. Perforated steel bands, with holes of varying diameter, are available and these give the strength and durability of steel bands but with improved ventilation of the product base. They are expensive. There are various wire bands ranging from the light square mesh types (such as 5 × 5, etc. describing the number of weaves per inch and weighing about 3.5 kg per square metre), to the looped wires which offer greater product support, improved durability and great flexibility at the terminal drums. Heavy flattened chevron type woven wire bands offer the extremes in band weight at around 19 kg per square metre. These bands are particularly favoured by producers in the USA but it will be appreciated that considerable power is needed to heat the band in the first part of the oven.

Provision is made to track the band to prevent it running over the edges of the terminal drums and thus damaging the structure of the oven or the band itself. To change a band is a large task and bands are expensive because of their considerable length.

5.6 Preparation and care of oven bands

Before a new oven band can be used for baking, it is necessary to prepare it. This involves conditioning and cleaning. The cleaning is principally a process of removing mineral oil and dirt, and in the case of wire bands this can be simply done by rubbing the band, after heating to about 150°C, with clean cloths. Steel bands (including perforated steel bands) require more attention in order to create a clean shiny surface which will not allow the product to stick while baking. It is customary to heat the band to about 150°C and to rub a fat into it, heat it through the oven and then to rub this off again at the oven exit with clean cloths.

A rough surface due to scratches, metal pitting or a buildup of carbon from charred fats or dough particles tends to cause product sticking. The conditions which cause the product to stick are not always obvious but a thin film of vegetable oil usually prevents the keying of sticky substances such as syrup or milk products which

develop on the base of products during baking. Products low in fat and high in sugars or egg may need a deliberate coating of the band prior to deposition of the product. Various 'greasing' arrangements are available that use vegetable fats or waxes like beeswax. The film of grease should be absolutely minimal and even. Even then an unacceptable spread of the product may occur as the sugars melt or dissolve as they are heated. This can be limited by an additional dressing of flour or starch on top of the oil film before the dough pieces are deposited. Mixtures of oil and a cereal may prove easier to apply than each separately. Proprietary blends of specially formulated release materials are available but their application is always critical. The inclusion of hydrocarbon (mineral) oils is strictly controlled in food applications. Their use as oven dressing is limited and in general should be avoided.

Whether oven band dressing is required or not, it is important to keep the band clean and equipment is usually provided as part of the oven design to do this. After the product has been stripped from the band, a scraper should be used to remove the largest particles of product adhering, thereafter, the careful use of rotating wire brushes or fabric buffing brushes may also be required. Too much brushing may remove the important conditioned band surface and very greasy brushes may merely redistribute the 'dirt' rather than remove it. As the band returns underneath the oven it is supported on rollers. If these rollers become excessively dirty, with buildup of biscuit crumb and grease, the action of the brushes may be impaired by subsequent deposit of more dirt.

If greasy or syrupy products are baked on wire bands, there will be a progressive buildup of carbon in the meshes of the wires. If this is loosened with brushes and not adequately cleaned off, black particles will adhere to the bases of the baked product. Therefore cleaning of wire bands is best attended to either before or after baking commences.

Excessive carbon buildup on a band can be removed when the band is warm, with scrapers, by hand or in exceptional cases using caustic soda treatments. If the latter method is used it is important that the caustic soda is both applied with great caution and is subsequently thoroughly removed by washing before product is baked again. Reconditioning of the band will probably be necessary.

Oven bands expand when heated and to preserve flat surfaces and reduce tensions, which may give distortions and difficulties with band tracking, it is most important to maintain even across-the-band

heating through the oven and to allow the temperature to fall to about 100°C before the band drive is stopped after baking finishes. Thus a cooling period is most important and this should not be done with the inspection doors open, down one side of an oven, as one side will cool faster than the other. Many ovens have automatic stopping controls that function after the oven and the band have cooled to the desired temperature.

If the oven band should stop during baking due to a power failure, two problems may arise. First, the product will quickly overheat and may actually ignite, and second the band will become excessively hot bringing the possibility of permanent distortion. There should be provision for automatic extinguishing of the oven heating in such a case and every effort should be made to wind out the band without delay. In some cases standby power, for example, from banks of batteries, may be provided but in any case crank handles which can be attached to the drive drum and wound by hand should be used immediately. It is important to provide a facility for collecting the burnt or burning product safely and the band should continue to be turned until power is returned or the band is cool enough to be left.

Rust can quickly ruin a band surface so if an oven is in a humid atmosphere and especially if it is not used regularly, it is wise to apply a film of oil or fat onto its surface. To prevent rusting on the inner surface of the band occasional light greasing should be provided in the form of silicon or graphite grease. Too much may result in drive slip on the terminal drum.

5.7 Starting up and shutting down of ovens

5.7.1 Starting up

1 **Heating the oven must start well before production is due to commence.** It takes at least one hour for most ovens to warm up to operating temperature and in the case of brick lined ovens the time may be even more.
   - Check that the oven band is tensioned and that there is nothing on the band at either end of the oven
   - Switch on the main power supply for the oven
   - Start the band and set it at a speed about half as fast as the bake time to be used
   - Close the flaps at the oven mouth and exit, over the oven band (if fitted).

Starting procedures are normally supplied by the oven manufacturer but the following will always be involved:

- Start the extraction fans and set the flues to a partially closed position
- For indirect fired ovens, start the circulation and baking chamber extraction fans and initially set the heat ratio controls for 50% top and bottom
- Check that the fuel supply is open
- Set the baking temperatures required as shown on the process audit chart
- Start the ignition system. This will probably go automatically through a purge routine before the burners are lit. (In some very old ovens and in countries where safety standards are not very rigorous, lighting of the gas burners in a direct fired oven may be manual and will involve going along the oven and lighting each burner with a torch.)
- Set the oven band to run at about half the speed shown on the process audit chart
- At intervals, check that the oven band is tracking correctly
- As the time for production approaches, check that the baking temperatures in each zone have been reached and that the burners are idling. If the temperatures are too high reduce the temperature set points and make a note that they should be set lower when start up occurs next time. Reset the temperatures as production commences
- Set the oven band to the desired baking speed as shown on the process audit chart
- Set the circulation, extraction systems and heat ratio settings as shown on the process audit chart
- Set the band cleaning gear as shown on the process audit chart.

2 **As production commences**:

- Ensure that the biscuit cooling conveyors, after the oven, are running
- Set the flaps (if fitted) at the oven mouth and exit, over the oven band, so that they just clear the dough pieces and biscuits at the oven exit
- Start the steam injection to the mouth of the oven, if required, as on the process audit chart
- Check that the panning of the dough pieces onto the band is correct; the spacing between the pieces is correct and that the transfer from the panning web is not butting or pulling the pieces

- Check the progress of the bake as it passes each inspection door and increase or decrease baking temperatures accordingly
- As biscuits come out of the oven, set the stripping knife or retraction conveyor to accept or reject the biscuits as appropriate
- As soon as the biscuits are of correct coloration, top and bottom surfaces, set the stripping knife or retraction conveyor to accept and pass the biscuits for cooling
- Take samples for quality measurements (see Section 8), make and record measurements, act as necessary
- Inform the packing department that biscuits are coming
- Check oven band tracking
- Set band cleaners as necessary
- Recheck baking temperatures and watch production until production has settled down.

3 **Breaks in the supply of dough pieces during a production run.**

The forming machine operator should inform if there is a stop or interruption of production and give an idea of how long the stoppage will be.

- For a very short stoppage, take no action but watch the restart expecting to reject some overbaked biscuits
- For a prolong stoppage, reduce the set temperatures to prevent excessive overheating
- At restart follow the appropriate stages as described for the start of production.

4 **Stoppage of the oven band during production.**

This will almost certainly be due to an electrical power failure but may also be due to a loss of air pressure used to tension the oven band. ACT QUICKLY

- The burners should extinguish automatically, if not turn off as quickly as possible
- Wind out, without delay, the oven band by using the crank handles provided. There may be a battery drive wind out facility that will operate automatically
- Keep winding the band for a prolonged period as it is important that the oven band does not overheat and become distorted
- Make sure that the overbaked biscuits that emerge from the oven, and which may catch fire, are disposed of safely and do not cause conveyors or other things to be burnt or damaged

- Open the extractions to their maximum and also the flaps at the mouth and exit of the oven (if fitted)
- Investigate the source of the stoppage.

When power is resumed restart by going through the start up procedure as if the oven was cold, as described above.

5.7.2 Shutting down

At the end of production:

- Turn off the burners and turbulence fans
- Turn off the steam if appropriate
- Open the extractions to maximum
- Lower the band cleaning gear
- Speed the oven band to about twice the baking speed, if possible
- Open the flaps at the oven mouth and exit, over the oven band
- Continue to run the oven band and extraction fans until the band at the oven exit is cool enough to be able to place a hand on it or until the oven indicated temperature is 100°C. In some cases the oven will stop automatically when the temperature is low enough
- Stop the oven band, extraction fans and turn off the power at the control panel.

6 Principles of baking

6.1 What happens in a baking oven

Baking is an important process but is very complex and difficult to understand and describe. The design of an oven is principally a matter of heat transfer and its control. For the baker what happens is a matter of temperature and turbulence at specific stages.

Heat and temperature are not the same and should not be confused. It is relatively easy to measure temperatures in an oven but much more difficult to measure heat, or heat flux, which is the rate at which heat is being transferred. Try to remember that heat is transferred much more effectively if the air is moving near the dough piece at a given temperature.

Nearly all biscuits are now baked in band or travelling ovens with several independently controlled zones. This means that oven conditions such as temperature, movement and humidity of the atmosphere may be altered during the course of the baking period. Baking times for biscuits are quite short, ranging from 2.5–15 min. It is not normally possible to change the temperature of a static or reel oven quickly so the results of baking in these ovens compared with those in travelling ovens are often very different.

The conditions needed for different types of biscuit are not the same because the way in which the structure is developed and the amount of moisture that must be removed depends on the richness (level of fat and sugar) of the recipe. The baking requirements for different types of biscuit will be considered later.

There are four major changes to the dough piece which can be seen as it is baked:

1 A large reduction in product density (the dough gets thicker) associated with the development of an open porous or flaky structure.
2 A change of shape associated with shrinkage or spread and increase in thickness.

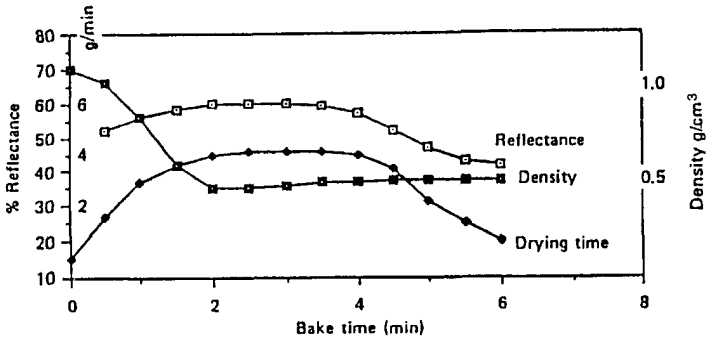


Fig. 4 Changes to the dough piece during baking.

3 A reduction in moisture level, to between 1–4%.
4 A change in surface coloration (reflectance).

Although these changes are thought of as being distinct and sequential, broadly in the above order, as the product passes through the oven, it will be shown that there is considerable overlap and coincidence of these physicochemical changes. It is, however, convenient to consider them separately first. Figure 4 summarises the changes that occur and relates them to dough temperature.

6.1.1 Development of biscuit structure and thickness

This takes place mainly in the first quarter or third of the baking period (see Fig. 5). The changes are all temperature related and involve several aspects of the recipe and formed dough piece. Bubbles of gas or water vapour are formed which expand and result in a large reduction in the density of the dough. The open porous structure gives a biscuit a pleasant eating texture. The development of the structure is often known as oven spring as it relates to the thickness of the baked biscuit. The conditions for giving maximum spring which is sustained through the remainder of the bake are imperfectly understood but the changes to the dough piece that are involved include:

1 Heating the starch and proteins to levels where swelling, gelatinisation, denaturation and setting occur.
2 Liberation of gases from leavening chemicals.

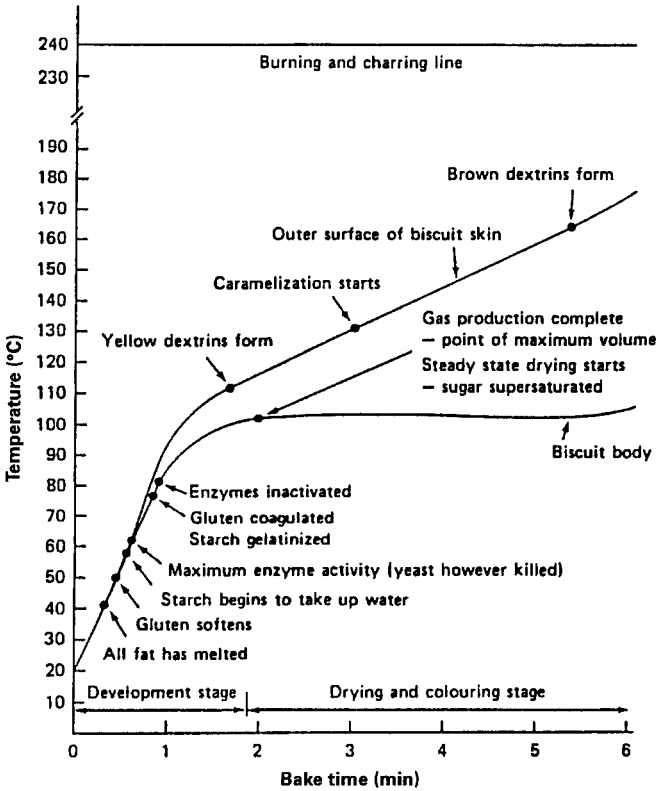


Fig. 5. Changes during baking (After Mowbray).

3 Expansion of these bubbles of gases as a result of increasing temperature which also increases the water vapour pressure within them.
4 Rupture and coalescence of some of these bubbles.
5 Loss of moisture from the product surface by evaporation followed by migration of moisture to the surface and continued loss to the oven atmosphere.
6 Increase in sugar solution concentration as the temperature rises.
7 Reduction in consistency of sugar solutions and fat with temperature rise.

It will be appreciated that the most important changes centre around the formation of gas bubbles and their expansion in a

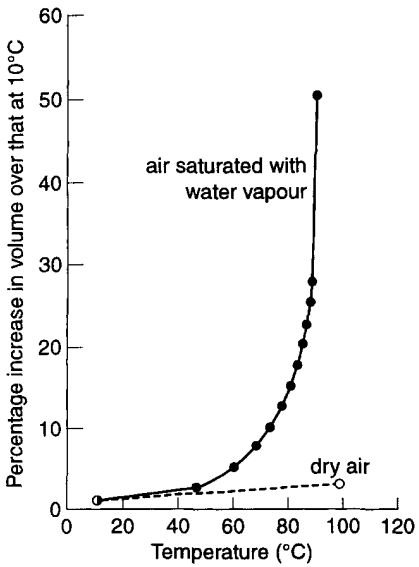


Fig. 6 Expansion with temperature of dry air and air saturated with water vapour.

medium, which first becomes softer and more flexible, followed, in low sugar and fat types, by tightening and hardening.

Many experimenters have shown that the increase in volume associated with the mass of gas that is liberated from leavening agents is inadequate to explain the magnitude of the oven spring in biscuits. Steam production is responsible for the extra increase that occurs because there is a dramatic increase in the volume of water as it changes to vapour. Although the expansion of the dough must in fact be due to water vapour, the term 'steam' is misleading because this word should be reserved for water vapour above 100°C. Consideration of the physics of water vapour pressure provides the answer. Figure 6 shows the increase in volume of air (or other gases like carbon dioxide) when dry and when saturated with water vapour. It should now be clear how the water vapour contributes to the expansion.

6.1.2 Reduction of moisture content

It would be ideal if moisture loss were to occur only after the structure has set. Clearly this is impossible as the dough piece starts

to dry as soon as it enters the hot oven atmosphere. During baking, moisture can only be lost from the dough piece surface so that migration of water to the surface by capillary action and diffusion must occur to enable the centre of the piece to dry. Both of these phenomena are accelerated by temperature gradients. The centre of the dough piece is heated principally by conduction of heat from the surface but as the crust dries it acts as an insulator and it becomes progressively more difficult to heat the centre. If the surface is heated too quickly, not only does it make it more difficult to dry the centre but colour changes occur prematurely. If a high heat continues, coloration will be excessive before the centre is dry. Thus baking is a matter of finding the best conditions of heat and time to allow structure development, surface coloration and drying of the centre. Thicker biscuits need longer bake times at lower temperatures to achieve this drying. Thin and small biscuits can be baked faster at higher temperatures.

The loss of moisture from the biscuit surface is related to the temperature, heat flux and water vapour pressure (humidity) at the surface. The idea of 'humidity' in the oven atmosphere can lead to a misconception in terms of baking conditions. No matter how much water vapour is present in an oven atmosphere which is at a temperature of more than 100°C, moisture will always be lost from the dough piece surface. The only conditions where moisture loss will be retarded is where the surface of the dough piece is at less than 100°C and the microclimate at the surface is saturated with water vapour. The desired moisture level of biscuits is determined by two main factors. Too low a moisture level will give the biscuit a burnt taste and perhaps a brown internal colour. At too high a moisture level the structure will not be crisp, the centre will be wetter than the edges and flavour changes associated with staling will be more rapid.

6.1.3 Colour changes

Although there is usually a change to a yellow brownish hue during baking, the term colour here is used to imply merely a darkening, reduction in reflectance, of the biscuit surface. There a number of reasons for the colour changes. The main one is the Maillard reaction, non-enzymic browning, which involves chemical reaction between reducing sugars in the dough with proteins and produces attractive reddish brown hues. This occurs around 150–160°C and will occur faster in a mildly alkaline situation and only in a moist

situation. It is not possible to reheat baked biscuits to make it happen. The protein in the dough comes from the flour and ingredients like milk powders and cheese. The reducing sugars do not come from sucrose but from ingredients like glucose syrup, invert syrup and milk powders. Most of the alkaline reaction is due to sodium bicarbonate. If this chemical is omitted from the recipe coloration will be much less.

Colour also develops associated with dextrinisation of starch and caramelisation of sugars. At even higher temperatures the biscuit structure chars or burns.

If the biscuit structure is very open, migration of moisture to the surface is slower and a local increase in surface temperature and therefore coloration can more easily be achieved. Thus well sprung puff dough will colour more easily than a dense puff structure.

An **excess** of alkali, usually resulting from too much sodium bicarbonate in the recipe, will cause a **general** yellowish colour throughout the biscuit structure. This is unattractive in products where there is no other coloration present.

As drying continues, coloration due to the changes already described will develop in the thinner or more exposed areas of the biscuit. This change is accompanied by the development of a bitterness in the flavour. A condition known as 'perishing' will occur if this continues throughout the biscuit structure. Perished biscuits are most unpleasant to eat!

The aim is to produce as even a surface coloration as possible except in crackers which have blisters. In order to prevent parts of the edges of the dough pieces becoming overcoloured it is important to arrange that they are placed close together on the oven band. Try to arrange that the spaces sideways are the same as those in line. Some adjustment of the spacing can be achieved when the dough pieces are panned onto the oven band. Where dough pieces are missing it is common for the edges of the surrounding biscuits to be coloured too much and these have to be rejected and not packed.

6.2 Oven temperatures and heat transfer

An oven is a hot box or tunnel which is designed to provide the desired conditions of heat and temperature for the dough pieces and to allow removal of moisture. Heat is provided by burning a fuel such as gas, oil or electricity and this heat is transferred by the three modes known as radiation, conduction and convection. All three

modes are always involved, although engineering techniques are used to enhance the effects of each separately. Oven design is determined by the constraints of providing efficient heat transfer, allowing rapid and precise control of temperatures under varying load conditions and providing heat in predominately one of the three modes required. All ovens fall short in one respect or another so an understanding of what is happening should help in setting an oven to provide the best possible conditions.

Dough pieces are supported on a baking surface which is usually a sheet of steel or a metal wire mesh. On entering the oven, heat is applied to the dough piece by a combination of conduction (through the baking surface), convection (from the hot air moving in the oven) and radiation (from the hot surfaces of the structure of the oven). Radiant heat, at the wavelengths involved, does not penetrate the dough piece significantly. The most effective form of heat transfer is by convection but moving hot air also sweeps away moisture and dries the dough surface very rapidly.

As the moisture evaporates from the product and as cool air, brought into the oven with the product, expands, there is a rise in pressure in the oven. In the case of direct fired ovens where gas is burnt in the baking chambers, the increase in pressure is even greater. This pressure must be relieved so flues are provided which exhaust to the atmosphere. If the pressure rise is exactly matched by the extraction rate through the flues, the oven atmosphere will soon become rich in water vapour. This is often referred to as humidity but because the temperatures are above 100°C, the concept of relative humidity used to measure the moisture content in meteorological terms is not applicable. The amount of moisture present has to be defined in terms of relative mass with respect to the air present, for example, grams of water in a given weight of air, or as the dew point – the temperature to which the air must be cooled before condensation occurs. To measure the moisture content of the atmosphere in an oven is not easy so it is rarely done!

The gases which are extracted are hot and represent a waste of heat. Great efforts have been made to devise means of limiting the extraction rates to a minimum. Although it would be possible to bake and dry a biscuit in an oven with a very 'damp' atmosphere the effect at the mouth of the oven should be understood. As a cold dough piece enters the warm humid atmosphere moisture will condense on the surface. This condensed water will release a lot of heat as a result of the latent heat of evaporation and this heat will be conducted into

the dough piece causing it to warm up rapidly. Later, as the dough temperature rises, this water will again evaporate and retard the rate at which the surface temperature rises. Wetting the dough surface at the oven entrance if the oven atmosphere is high in water vapour aids the general rise in temperature of the dough piece and maintains the flexibility of the 'crust' longer than if the oven atmosphere is dry. However excessive condensation on the dough surface can cause uneven coloration and spotting where sugar is locally dissolved. Provided that the moisture film is not excessive, a solution of surface sugars may give the biscuit an attractive 'bloom' later in baking. The humidity of the oven can be deliberately increased by injecting live steam. Drying of the dough piece surface may also be retarded by spraying with water before placing in the oven.

Apart from this effect of a damp oven atmosphere it has been difficult to be sure about the benefits, or otherwise, of moisture vapour content in the oven atmosphere to the baking performance. Reducing the extraction rates of flue gases to increase the oven humidity may also affect the convection currents and thus heat transfer rates. It would seem, theoretically, that the moisture level of the oven atmosphere is irrelevant but many critical tests have suggested that oven spring is reduced at high moisture levels.

It would be ideal if the dough piece could be heated uniformly and rapidly before much moisture is lost. This means that air movement at the dough surface should be minimum. In conventional ovens it is not possible to apply heat fast enough to the surface (and at a low enough temperature to prevent coloration) merely by conduction and radiation. Some preheating of the oven band before the dough pieces are placed upon it is desirable to promote heat transfer by conduction.

After the dough has expanded and the structure has set, it is necessary to concentrate on moisture removal. Air movement will keep the temperature and humidity at the dough piece surface favourable for this to occur. However, as the biscuit dries, conduction of heat from the surface to the wetter centre becomes progressively more difficult and a large moisture gradient will develop.

During this drying phase and before the surface becomes too dry, the temperature may be adjusted to give a desired level of coloration to the biscuit.

It is important throughout the bake that oven atmosphere conditions are kept even across the width of the oven. If this is not

done dough pieces which are similar at the entrance to the oven will appear as biscuits with different thickness, shape or colour after baking. In many ovens the movement of gases in the oven is not ideal. A common problem is that too much air to replace that pulled out through the flues enters at each end of the oven. There is thus considerable cooling due to this ingress of air and the effective length of the oven, and therefore the baking time, is thereby reduced. Also it is usual to find that there are inspection doors down one side of the oven only. If air enters through these as a result of bad seals, etc., that side of the oven will be cooler.

6.3 Baking of laminated cracker biscuits

'Laminated' means that the dough has been reduced to a thin sheet and this sheet has then been piled up into a number of layers, with or without the introduction of another material between the layers, and the pile has been further gauged to a final dough sheet for cutting. The term 'gauging' is used to mean the reduction of sheet thickness by rolling between a pair of rollers.

There are two basic forms of biscuit structure, those where a more or less even bubble formation is required and those where some large cavities are formed. Water biscuits, cream crackers, soda crackers and puff biscuits are examples of the latter. The baking conditions required for the two types of structure are very different and are determined by the formation of a different number and type of gas nuclei which are subsequently expanded by water vapour. The large nuclei in the cracker and puff types are derived from discontinuities in the dough produced by layers of fat or skins of drier dough resulting from lamination. Rapid heat input causes great expansion of these long flat nuclei (lenticels) which result in blistered and flaky structures.

Thus efforts are made to raise the temperature of the dough pieces quickly as they travel into the oven by using high temperatures followed by lower temperatures to effect the drying out. Considerable power is needed to raise the dough piece temperature and this is aided by using light wire bands often combined with band preheating. In the case of soda crackers typically, a heavy woven wire is used which has been heated before the dough pieces are placed on it. In this way heat conducted to the base of the dough pieces is at a maximum.

Laminated cracker dough is one of the wettest biscuit doughs and

weight losses of around 26%, dough piece to biscuit, occur in the oven. This means that provision must be made for adequate extraction during baking. The optimum 'humidity' level within the oven is still uncertain but there is evidence that high humidities impair biscuit development.

During baking, the laminations lift apart irregularly and this is how blisters may form on the biscuit surfaces. The mechanism of this lift is principally as a result of the discontinuity formed between thin sheets of dough (the laminations) by the cracker dust filling, or by skinning caused by flour, or by the dough drying out. The lenticular cavities which are formed initially expand as the air warms, but the greatest expansion results as the water vapour pressure rises when the dough piece temperature reaches 60°C and more.

Eventually the gas bubbles burst. At this point the gluten and starch structures in the dough should have been coagulated and gelled by the heat to form a structure that does not collapse completely before the biscuit has dried out.

Some of the carbon dioxide from the yeast (in a fermented dough) or by decomposition of the aerating chemicals will form minute bubbles which will swell the structure of the dough that forms the laminations. This mechanism contributes to a soft texture in the baked biscuit.

High temperatures at high speed give the best cracker structures.

The desired background colour of baked laminated crackers is fairly pale and relief is given because the blisters colour preferentially. If the spring of the dough is not good during baking the colour will seem pale because of the lack of this relief.

There are at least three common problems associated with baking laminated crackers and they act together to compound each other. One problem, which has just been mentioned, is that if the blisters are too pronounced, they will tend to colour or burn very easily. These big blisters will be damaged in post-oven biscuit handling, giving the biscuits an untidy, damaged appearance.

A heavily blistered biscuit will tend to have a dense general structure. This gives a hard or flinty type of texture. Bad blistering can be the result of poor lamination structure caused by insufficient filling dust, a dough quality that is unable to form thin laminations or damage to the laminated structure by crushing or pulling in the final gauging sections. Too hot an oven may cause bad blistering but this is usually subsidiary to one of the other possible causes.

A second problem of baking is the phenomenon of checking –

delayed fracturing of the biscuit structure such that the biscuit falls apart as if broken. This becomes apparent only some hours after the biscuit has been baked (see Section 6.5). It should be emphasised that checking is not normally a problem but its occurrence is unpredictable. Attention to detail in the dough preparation and laminating are important but it is probable that dough quality is also a contributing factor.

A third common baking problem is in flatness of the baked biscuit. It is extremely important that the biscuits are relatively flat for packing. A domed or dished cracker can be easily damaged at the packaging machine, or in the feeders immediately prior to it. The flatness can be controlled by the disposition of the heat above and below the band at the front of the oven. Too much top heat transfer either by radiation or air impingement will cause doming; too much bottom heat will cause dishing. The fastest that cream crackers can be baked is about 3 min. More normally the baking time is between 4.5–5 min. Water biscuits and soda crackers are often baked faster.

Typical temperature profiles are given in below:

Baking time	Zone 1	Zone 2	Zone 3	Zone 4
3.0 min	310°C	290°C	270°C	250°C
5.5 min	250°C	250°C	240°C	210°C

The faster the bake the higher the temperatures must be at the front of the oven.

The appearance of the crackers as they leave the oven will be determined by the design of the cutter used. In all cases some shrinkage will have occurred in the direction of travel. The amount of this shrinkage and thus the length of the crackers can be controlled to a certain extent by the relaxation of the dough before cutting. Crackers that were cut with a cutter which had scrap all round each piece will have a uniform coloration at each edge. Those from a cutter that did not have scrap at the sides of each piece and were panned onto the band as wide strips, will have darker front and back edges than at the sides. Owing to lateral dough shrinkage these strips of dough pieces will have broken and will now not be complete across the band. There will typically be one or two places where the biscuits have separated laterally but unless special provision has been made on the cutter, these positions of separation will be more or less at random. Typically the breaks will be at least a third way in from the edge of the band. Where the strips have separated, the biscuits will

have a little more colour round the edges. This is always the case for the pieces at the ends of each row. Those crackers with three edges, compared to only two, exposed to hot oven gases will have different edge to centre moisture distributions. Furthermore, where a separation occurs the position of pieces relative to the corresponding ones before and after them on the oven band will be out of line. The biscuits in a strip are separated, cracked apart, by a system of discs used to flex the baked strips on the lines demarcated by the cutter, first one way and then the other. Significant misalignment caused by separation during baking may result in damage to some crackers by these discs. It is therefore common that arrangements are made on the cutter for slightly greater imprints to be made, at say one-third and two-thirds of the distance across the band, to encourage regular separation within the strips during baking.

6.4 Baking of semi-sweet and non-laminated cracker biscuits

These biscuits are made from developed and extensible, doughs. To obtain an even round cell internal structure it is necessary to allow expansion before significant setting of the structure precludes further expansion. Setting the structure is a combination of gelatinisation of the starch/protein matrix and hardening due to moisture loss. There is a requirement in the first part of an oven, where structure development is occurring, to conduct heat to the dough piece as quickly as possible with a minimum of moisture loss at the surface. Thus high temperatures and air turbulence are not desirable. A typical baking profile is:

Baking time	Zone 1	Zone 2	Zone 3
5.5 min	160°C	200°C	180°C

There is a considerable amount of moisture to remove from the dough pieces during baking and this is aided if baking is on a wire mesh or perforated steel band. However, some hard dough biscuits are baked on a steel band and these are said to be more tender eating and less hard. The bake time is always longer.

A prerequisite for these types of biscuit is a smooth surface of even fairly pale colour with a sheen. The smooth surface and even lift are determined by the condition of the dough surface after sheeting and gauging and the sheen can be enhanced by passing steam into the front of the oven to increase the humidity of that

section so that it exceeds the dew point at the dough surface, allowing a film of moisture to be deposited on it. However, excessive steaming may cause a mottled coloration of the biscuit surface and fine blistering.

The importance of dough piece dockering should be mentioned. By creating air passages right through the dough piece, crust formation is encouraged and this reduces the chance of big blisters arising. The greater the aeration and faster the temperature rise in the dough piece, the more important are the docker points. All but the smallest cracker and semi-sweet hard doughs require the dough piece to be dockered. Like laminated crackers, the biscuits shrink during baking and some control of the biscuit length can be achieved by attention to the amount of dough relaxation allowed before cutting.

Control of the thickness of these biscuits is generally by the amount of aerating chemical used in the formulation. Some additional control is available in the front temperatures of the oven, particularly the top heat in the first zone of the oven.

Checking is again a potential problem in these biscuits. Using higher first zone temperatures may give early coloration and not allow enough heat or time for sufficient moisture removal later in the bake.

5.5 Checking

As the moisture gradient across a dough piece increases during drying, stresses may develop due to shrinkage of the starch and protein structures. While the biscuit is hot the structure is flexible and the stresses can be relieved. However if the moisture gradient is still high after the biscuit has left the oven, as the biscuit cools and the structure becomes more rigid, equilibration of the moisture through the biscuit may cause cracks to develop. This condition is known as 'checking'. A 'checked' biscuit typically has a fine crack across part of the centre and will break completely at the slightest handling. The crack develops because the migrating moisture causes the outer parts of the biscuit to expand while the centre shrinks. Stress cracks usually develop along the length (direction of travel through the oven) of crackers. Poorly developed crackers, with or without blisters, tend to check more than more open biscuits with better general lift.

Checking typically does not appear until about 24 h after the biscuit has cooled so it is not a problem that a baker normally

encounters during production. If checking does cause a problem an immediate way to tackle it is to bake to lower general moisture levels. This usually means longer baking times at lower temperatures, a situation that not only affects production efficiency but also will affect the spring of the biscuits during baking.

The overall shape of the biscuit and the positioning of the docker holes has an influence on the rate of moisture removal from the centre parts of the biscuit. The checking may therefore be a feature of a badly designed cutter.

There are other methods of reducing the problem of checking and these will be mentioned in Sections 7 and 9.

Not all biscuit types are prone to checking. Products with more fat or sugar have a more plastic structure so that stresses are more easily relieved as the biscuit cools. There is less moisture removal in the oven because the dough is less wet and the moisture gradients are much less pronounced. Thus it is more important to control the moisture levels in crackers, semi-sweet and other 'lean' products than other types of biscuit.

6.6 Baking of short dough biscuits

Products which are rich in fat and sugar have less water in the dough. This means that the protein is imperfectly hydrated to form gluten and when the dough is heated there is insufficient water present to gelatinise much of the starch. The structure relies more on a sugary or toffee-like matrix which becomes softer rather than sets as the temperature rises. Thus during the baking of sugar-rich short doughs an expansion, in all directions, is observed followed by some collapse in the thickness. The spread of the dough piece and collapse are responsible for the cracked surface of biscuits like ginger nuts and crunch types. The amount of this spread for a given recipe can be controlled somewhat by the following baking techniques:

- Factors allowing greater spread
  - Greasy surface of the baking band
  - Cold band as the dough pieces are deposited
  - Low temperatures in the front of the oven.
- Factors which reduce spread
  - Flouring of the baking band
  - Warm oven band before panning of dough pieces
  - High oven temperatures in the first zone.

Other non-baking factors which affect spread are described under *Troubleshooting*, Section 8.5.2.3.

Doughs which spread appreciably during baking cannot be baked on open wires as they would sink deeply into them. Although a flat steel band is best, some may be baked on woven wires.

Many short doughs with low fat do not spread during baking and can be baked on wires. These types of short dough biscuits may require docker holes to achieve a flat baked biscuit and to allow good moisture removal from the centre parts. However checking in all but the largest short dough biscuits is unusual.

Baking times are generally longer than for hard dough biscuits because lower temperatures are required to prevent excessive coloration. The baking times are related to biscuit thickness and short dough biscuits can be very thick and are generally thicker than hard dough types. Baking profiles are usually flat at about 180°C for all the oven zones.

For sugar-rich types the surface cracking can be greatly increased by spraying water on the dough pieces before the oven or by injecting steam into the mouth of the oven. This ensures that the dough surface remains soft and flexible for longer during the bake allowing greater development of thickness and spread before collapse which gives the cracks.

Most short dough biscuits are soft and flexible as they leave the oven. This means that they are more difficult to strip from the band. Cooling soon sets the sugary structure so enough oven band run out after the oven is necessary to allow this to happen naturally, otherwise air must be blown down onto the biscuits to hasten the cooling/setting.

7.1 Run out of the oven band and stripping biscuits from the band

A flat blade or a set of fine fingers bearing on the oven band as it curves downwards on the terminal drum is designed to lift the products clear and transfer them with minimum damage and minimum disruption to the relative positioning of the biscuits. The blade or set of fingers is known as the stripping knife. The biscuits are pushed by successive rows of biscuits onto the first cooling conveyor or fall onto a cross conveyor. The first cooling conveyor is usually quite short and may be wire mesh or cloth fabric. It is possible to retract the nose piece of this conveyor immediately behind the oven stripping knife or fingers so that burnt or bad biscuits may fall down onto a cross conveyor to be collected for scrap (see Fig. 7). The whole unit is known as the oven stripper and is powered by the oven drive. Its speed is usually slightly faster than the oven band to allow some separation of the rows of biscuits.

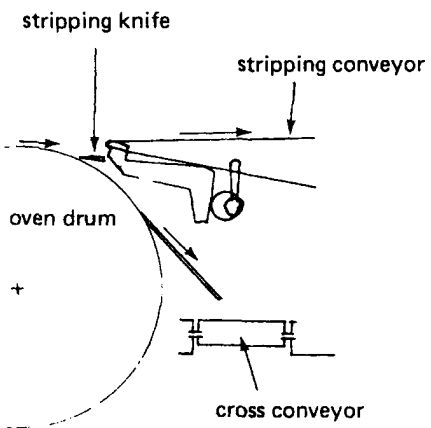


Fig. 7 A reject system before oven stripper conveyor.

Should the oven band stop during production, for example, as a result of a power failure, it is necessary to move the oven band either using an auxiliary power source or by means of a handle. In either case, there is usually a short delay before the oven band is moved again. Initially it will move then rather slowly. Under these conditions it is not unusual for product to emerge from the oven and to catch fire. It is important that this hot product does not fall onto any canvas cooling conveyors or they may ignite and the fire may spread. The oven stripper conveyor, if made of wire mesh, provides a safe buffer from which burning product can be swept onto the floor or into suitable containers.

7.2 Electronic drying

Instead of passing from the oven band onto cooling conveyors the biscuits may be passed onto a non-metallic conveyor and passed through a radio frequency drying unit.

The conveyor and biscuits pass between sets of electrodes above and below the conveyor. An alternating electronic field, at radio frequency, is established between the electrodes and this passes through the biscuits and preferentially heats the wettest parts by activating the water molecules. The spacing between the electrodes has to be critically tuned to achieve the maximum heating action from the electronic field.

Water that is heated in the biscuits is driven to the surface and lost. In this way moisture gradients which may persist after baking and which could result in checking, are reduced significantly. Conventional baking ovens are inefficient in removing the last traces of moisture from biscuits. They are much better for developing structure and for colouring the dough pieces. Using an electronic drier allows biscuits to leave the oven much wetter than usual so that the baking time can be reduced and production from the oven increased. It is claimed that by using post-oven dielectric drying it is possible to increase the output of a conventional oven by up to 33% although this is a rather optimistic claim.

This process is limited by the fact that semi-baked biscuits must be rigid enough to be transferred from the oven band over a stripping knife and onto a canvas conveyor. The closer the drier is to the oven mouth the better, as the hotter the biscuits are as they go into the drier the more effective is the heating from the dielectric field.

7.3 Oil spraying

In an alternative process, biscuits leaving the oven band pass into an oil coating unit. For many savoury cracker biscuits, and also some other types, a dressing of oil is given while the biscuits are still hot. Immediately after the biscuits are taken from the oven band they are passed through a unit where they are sprayed with warm vegetable oil. The oil is distributed either from pressure nozzles, spinning discs or by electrostatic charge. All types except the last tend to be messy because fine droplets of oil form a fog that will drift from the spray unit unless there is positive extraction and filtering.

The biscuits are carried through the unit on open wire conveyors. The oil dressing, applied at around 5–10% of the biscuit weight, greatly improves the appearance of the biscuit surface, enhancing the colour, and adds to the eating quality. The excess oil falls through the conveyor and is recycled. In some cases flavoured oil is applied. This is a useful technique for applying flavour to savoury or hard sweet types that would otherwise be lost if added into the dough before baking. The main problem associated with flavoured oil is that it contaminates the cooling conveyors used to hold the biscuits when they leave the oil spray unit and the smell may fill the packing area of the factory.

8.1 Introduction

It has been shown how the heat and temperature profile is important for development of the product structure, drying and coloration. In the various types of ovens, controls are provided to set zone temperatures, alter the amount of air turbulence, direct the proportion of heat directed to the top and to the bottom of the band and determine the rate of extraction.

How is a desired set of conditions established? Perhaps more important, how can a set of conditions which has been shown to give a satisfactory product be returned to at different times and be maintained precisely?

Although biscuit ovens have several independently controlled zones there is usually significant movement of air from one zone to the next because the ingress of air replacing the air being extracted has not been specifically controlled. Thus, it is not unusual to find that there is a draught into the oven at both the mouth and the exit. This effectively reduces the length of the oven because the air being drawn in is cold. Entry of cold air should be minimised by closing the extraction.

The means of controlling oven conditions other than temperature are usually crudely calibrated and often, even though their scales are linear, the effects are far from linear. This is particularly the case, for example, in extraction dampers. Few ovens have any indication of air flow velocities or humidities. In most cases thermometers or thermocouples used to detect oven atmosphere conditions are few in number and are so positioned as to give poor information about the conditions at, or very near, the dough pieces being baked.

As there is normally only one set of oven inspection doors per oven zone, visual checks on the effects of oven conditions on the dough pieces being baked are limited and the baker has to use his or her experience, of inspection of the biscuits emerging from the oven

to decide whether the various zones in the oven are performing as required.

'Optimum' oven conditions are established principally by trial and error and adjustments from time to time rely on experienced operators. There will be small differences in the oven settings related to ambient temperature, the wind speed outside the factory (this affects the extraction rates of the flue gasses) and variations in the ingredients in the formulation of the dough. It is very important that a process audit chart is constructed to record all oven settings and readings at a time when production was proceeding well. This processing record will form the basis of settings for starting an oven each day. Operators and others should be encouraged to check the records periodically when production is running well and to note any deviations, with the date and any notes on why the settings may have been different. In this way smooth and efficient running of ovens will become the norm.

8.2 Measurement of weight, size and colour

As biscuits emerge from the oven their quality can, for the first time, be seen and measured. It is the responsibility of the baker to use the information and, when necessary, to initiate process adjustments that will keep the product within specification.

The biscuits will not always be exactly the same weight, size, colour, etc. There will always be some slight variation and this must be accepted when a specification is agreed. To acknowledge the variation the baker should be provided with process control record charts that allow him or her to record the measurements that he or she has made and show visually when the biscuit is out of specification and some action is required.

A typical process control chart is shown in Fig. 8.

It is not the job of the baker to design these charts but it is the baker's job to record ALL the measurements that he or she makes not just those at the timed intervals that represent the minimum of test measurements.

Measurements of weight are the single most important process control checks. When these are being made the number and sampling system used are very important. Biscuits should be sampled in a manner that reflects the way they will be collected for packing. Thus the number of biscuits and the position on the oven band must be considered. Should one biscuit from each lane (a line running down

DAILY PLANT RECORD SHEET

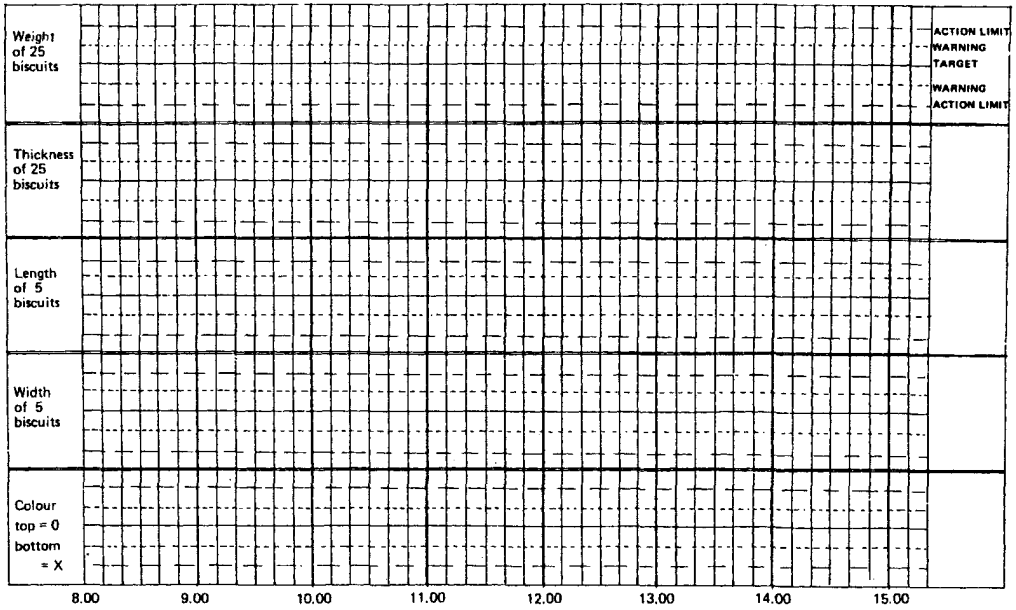
Date

Plant number

Biscuit type

Rows per minute (std)

Baking time (std mins)



A typical process control chart.

the oven) or x biscuits from one lane be taken for measurement? If it is known that there is commonly a weight variation across the oven band perhaps an 'across the band' sampling system will be best.

Having weighed the biscuits (and recorded the result!), use the same biscuits to measure the thickness, width, length and/or diameter. It is best to use a number of biscuits for these parameters since it is difficult to measure one biscuit with the necessary accuracy. The testing procedure should require that a pile of biscuits, of defined number, is used to check the thickness, and that a defined number is laid side by side to measure the length, width or diameter. The record charts should allow the baker to note the actual measurements that are made, but not require the baker to divide by 4, 5 or the number of biscuits that were taken. From the record chart it will be possible to see immediately whether the biscuit is within specification and if it is not whether some action should be taken. The inner action limits require immediate re-sampling and action if this second measurement is also outside the limit. The outer action limits require immediate action as the process is certainly out of control.

Assessing biscuit colour requires either an instrument which measures reflectance – check both the top and bottom surfaces – or comparison with standard samples or photographs. Problems will arise when there is no instrument because it is impossible to describe colour accurately in terms of figures. Photographs and biscuits placed for reference fade with time. In best practice, a manager or process control technician selects samples that represent the darkest and palest colours permitted and ensure that they are replaced regularly.

The baker should note when the oven settings have to be changed to correct dark or light baking conditions.

8.3 Measurement of moisture content

Measurement of moisture is not quite as simple as are the checks for weight and size. Either a sample of ground up biscuit must be heated under precise conditions and the loss in weight noted or the ground sample must be analysed on a specially calibrated electronic instrument, for example an infrared absorption meter.

The frequency with which tests for moisture are made is also worth thinking about. A settled oven producing biscuits of correct weight, size and colour at the normal production speed will probably

have also dried the biscuits correctly. The quality of some biscuits is sensitive to the moisture content. For example, if the biscuits are too wet they will be soft or develop cracks later. If they are too dry, they will have a poor and bitter taste. Most companies require moisture tests to be made at least once per hour but it is advisable that the tests are made more frequently at the beginning of a production run until the oven settles down, and also for particularly sensitive products.

Record **ALL** moisture tests made.

8.4 Communication requirements

Emphasis has been made about the need to record **ALL** post-oven measurements that are made. If they are not recorded it can be assumed that they were not made! The records also provide an indication of the **trends** of a particular biscuit parameter and also how often process adjustments have to be made. Considerable variation in the biscuit parameters should prompt action by development technologists to improve the process to make it more stable.

It is important to act and communicate correctly when out of specification product is discovered. Consider the implications for the packing department. Should the biscuits be packed or rejected? Will there be problems in fitting the biscuits in the packets? In addition to taking action which should bring the product back into specification, correct communication warns others that there may be problems which will require them to make decisions or to seek instruction from the production manager.

8.5 Troubleshooting

Difficulties in baking and biscuit faults that are noticed when the biscuits leave the oven are the result of processing that took place before the biscuits reached the oven. Correcting biscuit faults is therefore often a production team problem not just a task for the baker.

8.5.1 Process mechanism and dependency diagrams

These diagrams (Fig. 9 to 17) may be useful in considering the possible causes of problems observed. They cover the more general biscuit characters. Other problems may be found in Section 8.5.2 on faults.

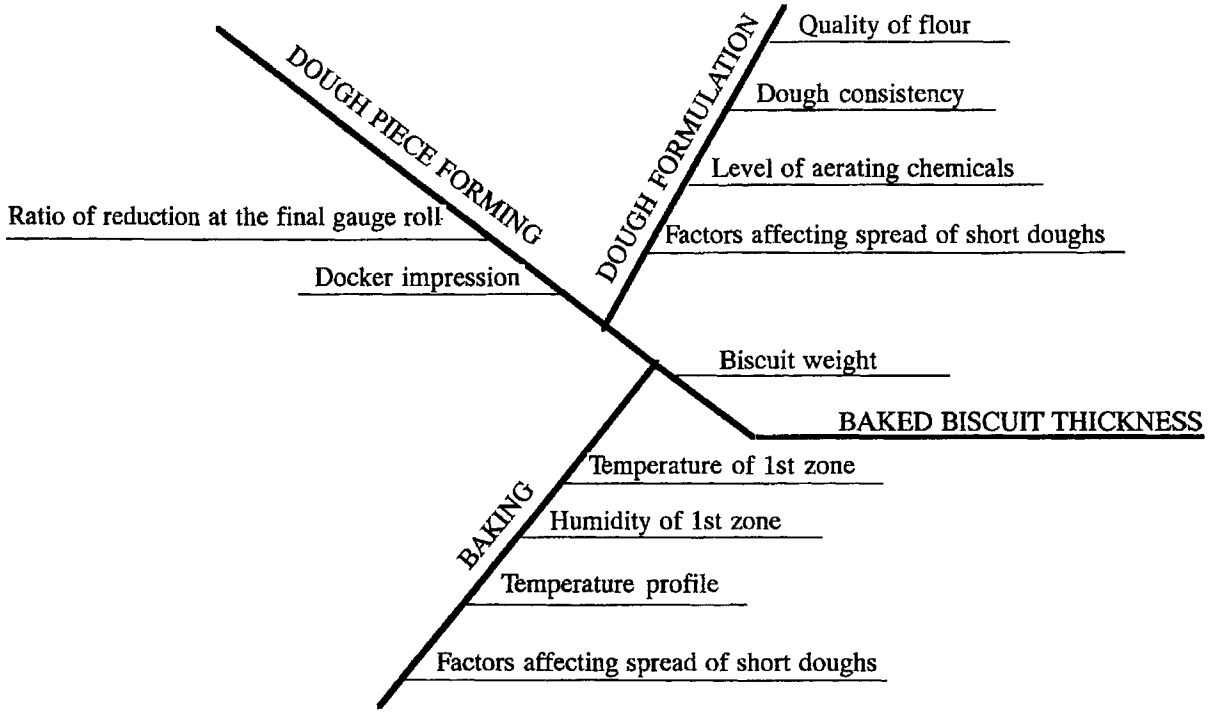


Fig. 9 Baked biscuit thickness mechanisms (see Sections 6.3 and 6.4).

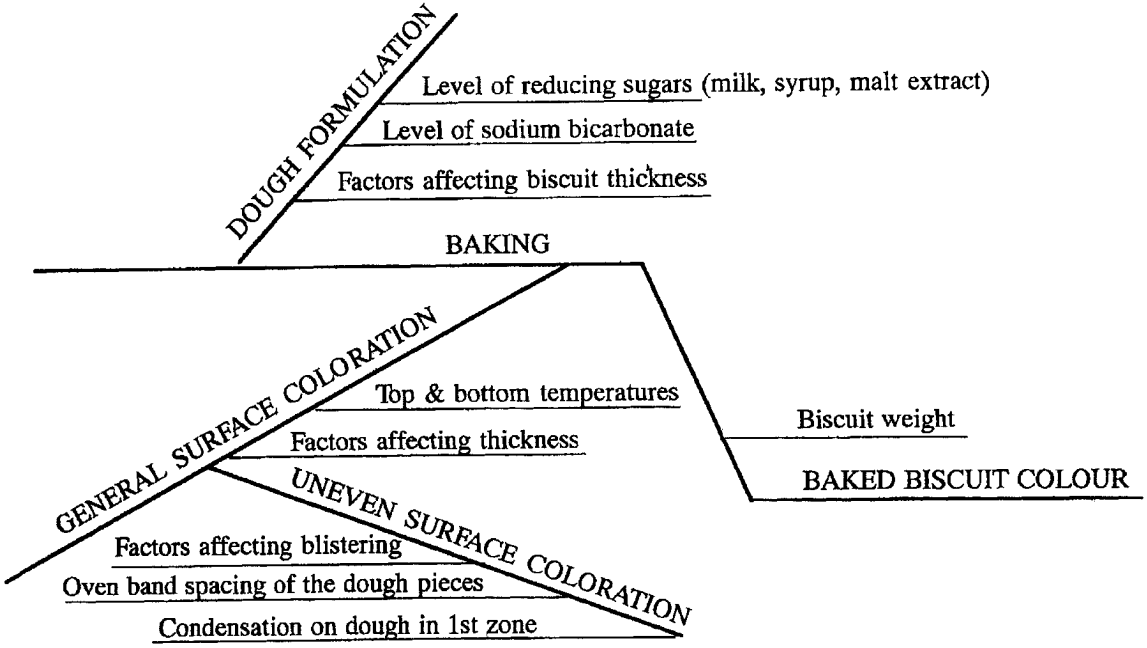


Fig. 10 Biscuit surface colour mechanisms (see Sections 6.1.3, 6.3 and 6.4).

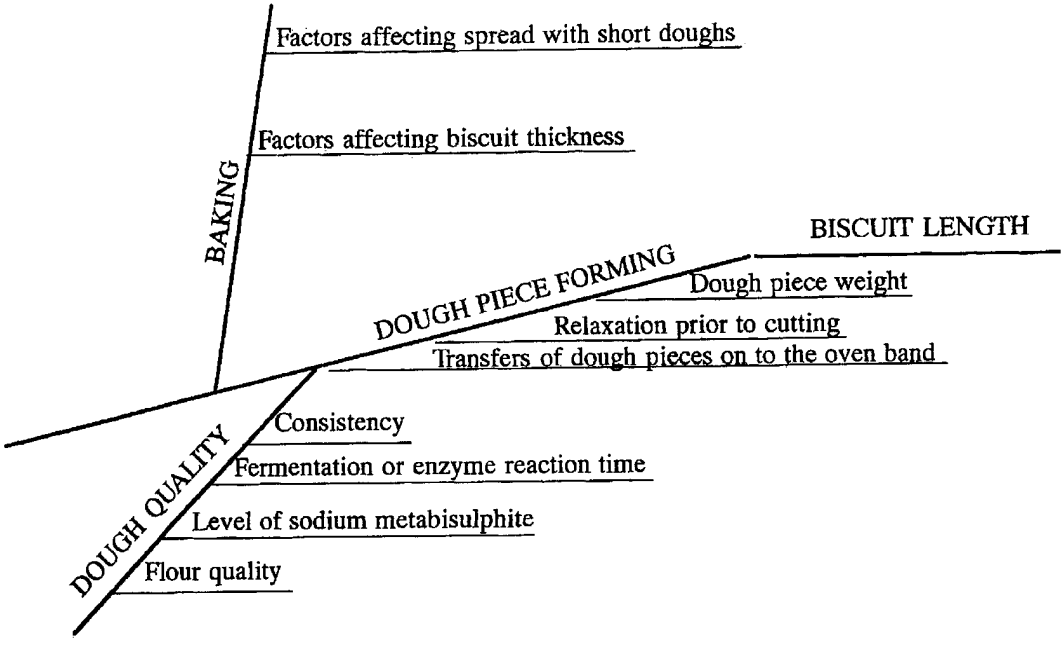


Fig. 11 Biscuit length mechanisms (hard doughs) (see Sections 6.3 and 6.4).

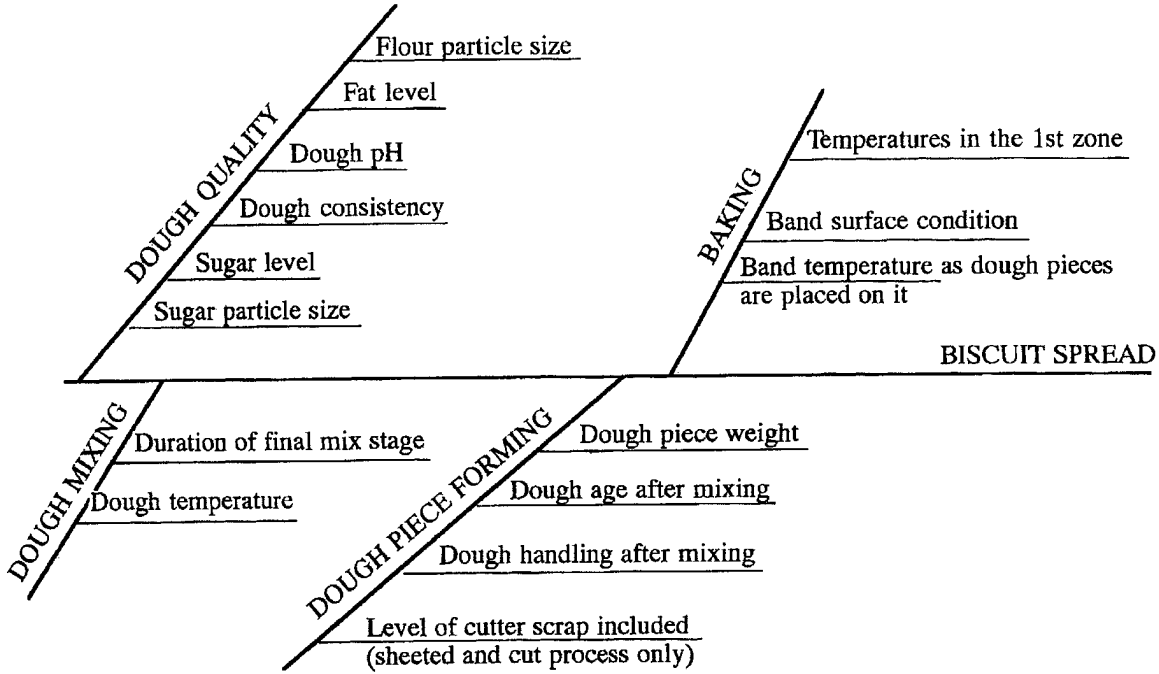


Fig. 12 Biscuit spread mechanisms (short doughs) (see Sections 6.6 and 8.5.2.3)

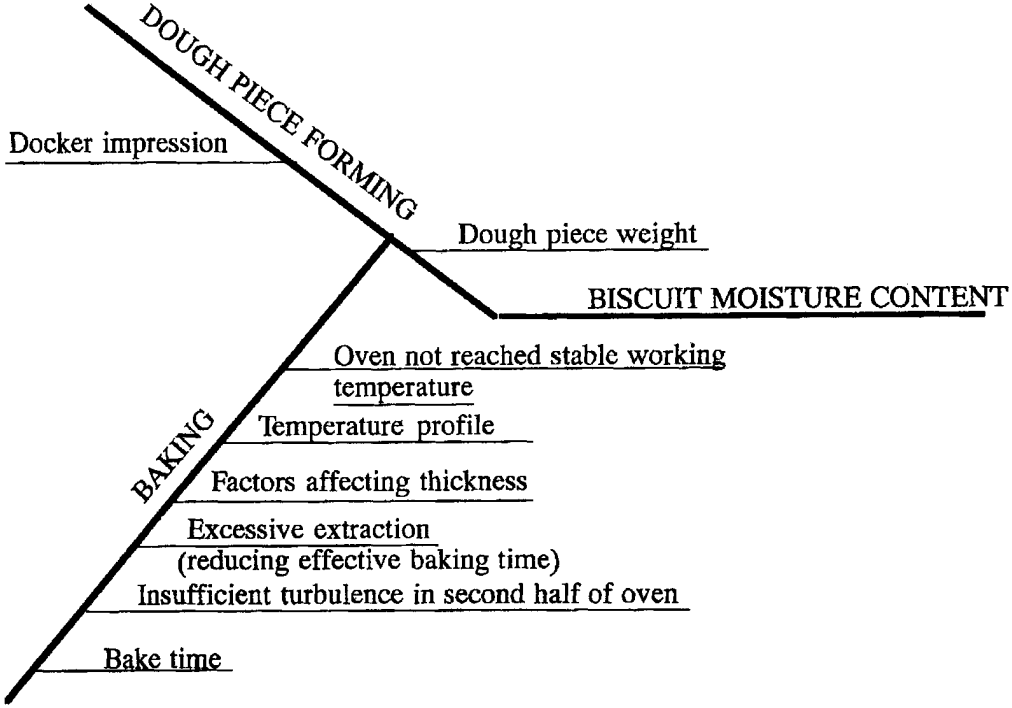


Fig. 13 Biscuit moisture content mechanisms (see Section 6.1.2).

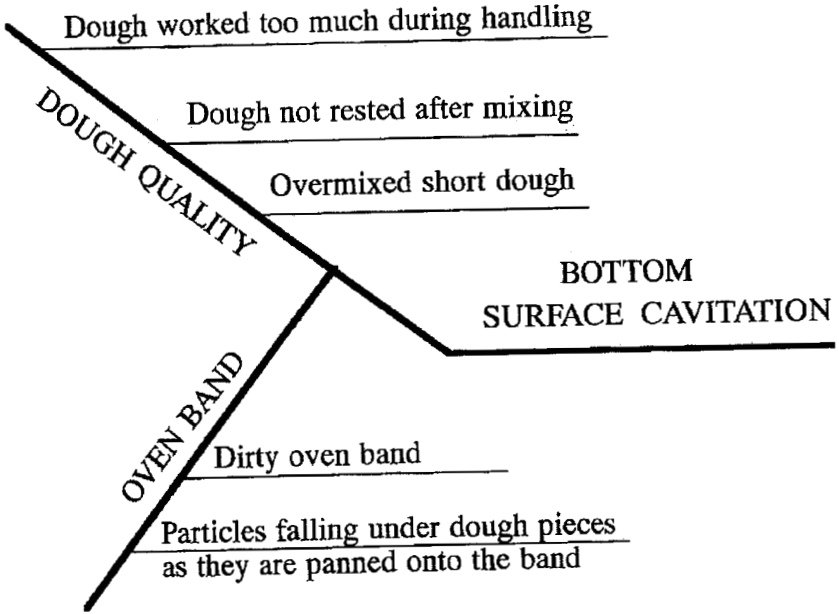


Fig. 14 Bottom cavitations (holey bottoms) mechanisms.

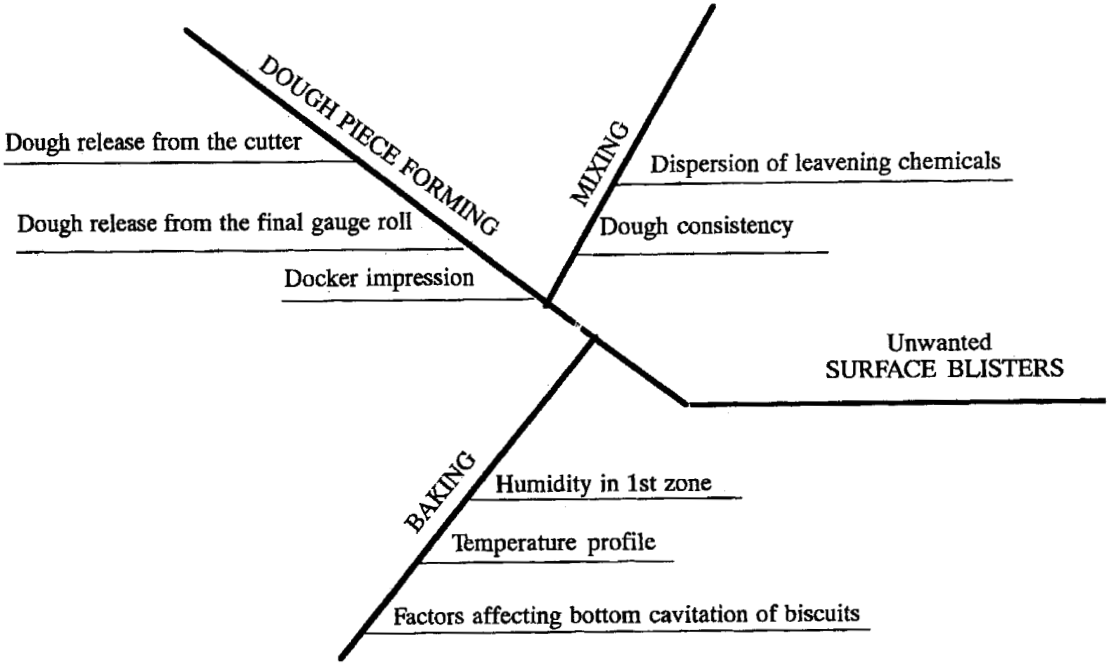


Fig. 15 Unwanted surface blister mechanisms (see Sections 6.2 and 6.3).

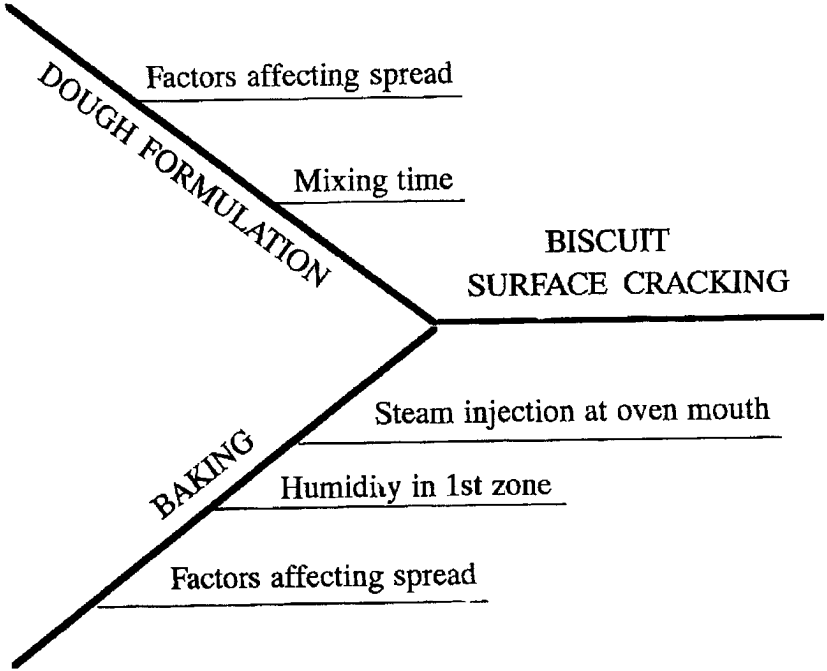


Fig. 16 Biscuit surface cracking mechanisms (short doughs) (see Sections 6.2 and 6.6)

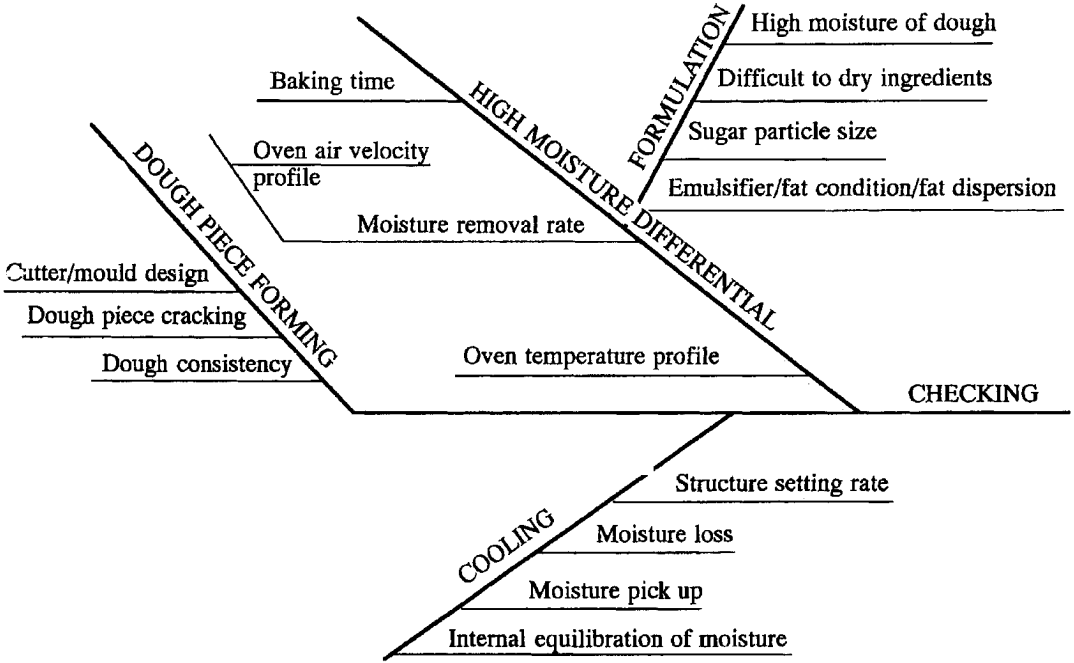


Fig. 17 Checking mechanisms (see Section 6.5).

The troubleshooting aspects of 'Checking' are also dealt with in Manual 6, *Biscuit packaging and storage*, where the problem is normally observed.

8.5.2 Faults found in different types of biscuits

In this section specific problems are listed with suggestions for corrective action. Some repetition will be observed from the mechanism diagrams. Where adjustments by the dough piece forming operator are suggested it is assumed that information given in Manual 3, *Biscuit dough piece forming* will be used.

In all cases it is assumed that the baking speed is as specified on the process audit chart and that production speed is **not** a variable factor.

8.5.2.1 Laminated hard dough biscuits and crackers

1 There is a poor development of structure, the biscuits are too thin (low stack height) and too long.
   - check the biscuit weight and request correction if necessary
   - can more heat be applied at the front of the oven? This will be by increasing the temperature and/or increasing the turbulence. For direct fired ovens opening the extraction may result in more turbulence as the gas flames will be larger
   - is there too much extraction in the first zone? This will be shown by drawing air into the mouth of the oven with the product and results in an effective shortening of the hot area in the first zone. Excessive extraction will also give a drier first zone which may dry the surface of the dough piece prematurely causing less thickness development
   - check that the gauging of the dough pieces is correct. Crushing at any of the gauge rolls will damage the laminated structure and reduce the structure development during baking
   - ask if the surface of the dough is smooth and clear as it is being laminated and gauged? A rough dough surface from the sheeter will indicate that the dough is not in good condition for developing a good laminated structure and this will reduce the structure development during baking. If it is rough only after gauging it is being crushed by overfeeding.
2 The baked coloration is pale.
   - check the oven temperatures against those required on the process audit sheet
   - check the biscuit weight and request correction if necessary

- check the biscuit thickness. Poor structure development is usually associated with pale baked colours
- check the biscuit moisture, if high, increase the temperature in the centre and at the last zones of the oven
- if thickness and moisture are correct ask for the mixing to be checked as there may be an error in metering of syrup, sodium bicarbonate, milk powder or other material that affects baked coloration. In the meantime, check the coloration on both surfaces. If pale only on the top surface try increasing the top heat in the first two zones.

3 The coloration around the biscuits is not even.
- check the placement of biscuits on the oven band. Spacing should be the same in all directions.

4 The surface blisters are too large, very fragile and are baking to a very dark colour. The biscuits are developing too much and are probably too thick in their stack height and may be too short.
- check the biscuit weight and request correction if necessary
- check that the docker pins are penetrating the dough piece correctly
- check the biscuit length and ask for a correction, see Section 6
- request that a check is made on the amount of filling dust or flour being used at the laminator, too much will cause extra separation of the laminations during baking
- reduce the first zone temperatures and/or the turbulence
- reduce the extraction in the first zone
- seek an adjustment of gauging settings or the number of laminations.

5 The biscuits are not flat.
- the biscuits tend to be drawn to the higher temperature in the first zone of the oven. If the biscuits are 'domed' (with the centres higher than the edges) try reducing the top heat or increasing the bottom heat. If biscuits are 'dished' (with the edges high compared with the centre) try increasing the top heat. Top and bottom heat can be adjusted both by temperature and amount of turbulence.

6 The biscuits are too long.
- check the thickness. Poor development of structure is often associated with a 'dead' dough that has little elasticity and therefore does not shrink during baking. If the thickness is poor refer to the first part of this section
- seek adjustment of the length by the forming machine operator.

7 The coloration is correct but the moisture content is too high.
- check the biscuit weight and request correction if necessary
- check the biscuit thickness and correct if necessary. It is more difficult to remove moisture from a poorly developed biscuit. Try to correct the thickness (see first part of this section)
- ask for the mixing to be checked as there may be an error in metering of syrup, sodium bicarbonate, milk powder or other material that affects baked coloration
- increase the temperature and/or turbulence in the last third of the oven.

8 The biscuits are hard and flinty.
- check the biscuit weight and request correction if necessary
- check the thickness. Poor development of structure is often associated with a 'dead' dough that bakes as a hard biscuit
- ask for checks to be made on the dough quality. Has the sodium bicarbonate or ammonium bicarbonate been omitted? Has the fermentation been correct? If there has not been enough development of the dough layers compared with the separation to form the flaky structure, the biscuit will be harder than usual.

9 The biscuits have dirty bottoms.
- the oven wire is dirty and carbon is coming off with the biscuits. Check the band cleaning machine. If a wire brush is used it must be followed by a fabric brush or pads to remove the loosened dirt
- try increasing the front bottom heat and then adjust the resultant change in baked colour in the next section of the oven
- try using a drier dough that does not sink as deeply into the oven band.

8.5.2.2 Non-laminated hard dough biscuits and crackers

1 There is a poor development of structure, the biscuits are too thin (low stack height) and too long.
- check the biscuit weight and request correction if necessary
- can more heat be applied at the front of the oven? This can be done by increasing the temperature and/or increasing the turbulence. For direct fired ovens opening the extraction may result in more turbulence as the gas flames will be larger
- is there too much extraction in the first zone? This will be shown by drawing air into the mouth of the oven with the product and results in an effective shortening of the hot area in the first zone. Excessive extraction will also give a drier first

zone which may dry the surface of the dough piece prematurely causing less thickness development
- ask if the surface of the dough is smooth and clear as it is being gauged? A rough dough surface from the sheeter will indicate that the dough is not in a good enough condition to develop a good structure and this will reduce the structure development during baking. If it is rough only after gauging it is being crushed by overfeeding
- ask for more leavening agent such as ammonium bicarbonate to be added to the mix.

2 The biscuits are too thick, the stack height is too high.
- check the biscuit weight and request correction if necessary
- are the biscuits flat? If not, check whether the docker holes correctly penetrate the biscuit and ask for an increased cut if necessary
- is the surface blistering? The reasons for this may be several. For example, Is the dough too soft? Is the final gauge roll surface sticky? Is the dough tending to stick to the cutter? If baked on a steel band, are there holes (cavitation) on the base of the biscuit related to the blisters? (see point 4 in Section 8.5.2.3, *Short dough biscuits*, below). There may be a problem with hydration or dispersal of an ingredient in the dough. Examine the dough carefully looking for small lumps
- try reducing the temperature at the front of the oven
- are the biscuits thicker at the front end? Check the transfer of the dough pieces from the cutting web and onto the oven band. Check the appearance of the dough piece after cutting and adjust the cutting roll speed if necessary.

3 The baked coloration is pale.
- check the biscuit weight and request correction if necessary
- check the oven temperatures against those required on the process audit sheet
- check the biscuit moisture, if high, increase the temperature in the centre and at the last zones of the oven
- if thickness and moisture are correct ask for the mixing to be checked as there may be an error in metering of syrup, sodium bicarbonate, milk powder or other material that affects baked coloration.

4 The coloration around the biscuits is not even.
- check the placement of biscuits on the oven band. Spacing should be the same in all directions.

5 The coloration is correct but the moisture content is too high.
   - check the biscuit weight and request correction if necessary
   - check the biscuit thickness and correct if necessary
   - ask for the mixing to be checked as there may be an error in metering of syrup, sodium bicarbonate, milk powder or other material that affects baked coloration.
   - increase the temperature and/or turbulence in the last third of the oven.
6 There is a poor surface sheen.
   - check the quality of the dough surface during gauging and cutting. It should be smooth and clear
   - reduce the extraction in the first zone to increase the humidity and cause some condensation on the dough surface as the pieces enter the oven
   - inject a **small** amount of steam into the mouth of the oven.
7 The biscuits have dirty bottoms.
   - the oven wire is dirty and carbon is coming off with the biscuits. Check the band cleaning machine. If a wire brush is used it must be followed with a fabric brush or pads to remove the loosened dirt
   - try increasing the front bottom heat and then adjust the resultant change in baked colour in the next section of the oven
   - try using a drier dough that does not sink as deeply into the oven band.
8 The biscuits are sticking to the steel band and the bottoms are being pulled out.
   - identifying correctly the reason for this problem may be difficult!
   - is the oven band dirty? If so clean it with the band cleaner
   - try increasing the bottom heat in the first section of the oven
   - try flouring the oven band
   - has the oven band been correctly conditioned? see Section 5.5
   - try using a drier dough
   - is the dough older than usual and has it more syrup or milk solids?
   - try increasing the dough pH with a little more sodium bicarbonate.
9 The biscuits are too long.
   - check the biscuit weight and request correction if necessary
   - check the stack height and correct if necessary

- ask for the dough pieces to be reduced in length at the forming machine.

10 The length of the biscuits is varying.
- this is almost certainly a dough or dough piece forming problem. Try to establish the pattern of the variation
- it may be due to non-uniform dough relaxation before cutting
- it may be due to variable cutter speed or a slack cutting web
- it may be due to variation in dough quality, for example, its temperature or age.

8.5.2.3 Short dough biscuits

1 The spread during baking is either too much or too little.
- check the biscuit weight and request correction if possible
- consider the factors detailed in Section 6.6 and Fig. 12.

2 The stack height is too great, the biscuits are too thick.
- check the biscuit weight and request correction if possible
- check the length, width and diameter measurements. If wrong refer to point 1 of this list on spread
- consider temporarily using a light roller at the oven exit to gauge the biscuits while they are still soft, but correct the problem as soon as possible.

3 The stack height is too low, the biscuits are too thin
- check the biscuit weight and request correction if possible
- check the length, width and diameter measurements. If wrong refer to point 1 of this list on spread
- ask for the final mix time to be increased a little to toughen the dough
- if you ask for aeration chemicals to be increased a little too much, the spread will be affected.

4 The biscuits have cavitation on the under side.
This is due to entrapment of gas under the dough piece early in the baking process.
- are particles of sugar or dough getting under the dough piece at panning?
- are there particles adhering to the oven band after cleaning which are getting under the dough pieces?
- is the dough over mixed and tough? Try reducing the final mix time or standing the dough longer before use in the sheeter or moulder.

Table 1 Spread factors in short dough biscuits

Factors allowing greater spread	*Factors which reduce spread*
Baking	
Greasy surface of the baking band	Flouring of the baking band
Cold band as the dough pieces are deposited	Warm oven band before panning of dough pieces
Low temperatures in the front of the oven	High oven temperatures in the first zone
Dough and dough piece weight	
Very fresh dough	Old dough
High dough pH, (more ammonium or sodium bicarbonate)	
High dough piece weight	Low dough piece weight
No cutter scrap with fresh dough	High levels of cutter scrap
Fat in the formulation	
Soft doughs due to higher temperature	Cold doughs
More fat	Less fat
Sugar in the formulation	
Fine sugar particles	Coarse sugar or lower level of sugar
Flour in the formulation	
Coarse flour particles	Higher flour water absorption value
Minimum mixing prior to dough standing	Over mixing of dough

5 Biscuit which should have a surface crack do not and have a smooth or 'blind' appearance.
   - check the length, width and diameter measurements. If wrong refer to point 1 of this list on spread
   - increase the humidity in the first zone, inject steam into the oven mouth or spray water onto the dough piece surface
   - try increasing the top temperature in the first zone of the oven.

6 The biscuits are sticking to the oven band and/or are difficult to strip from the band.
   - increase the cooling after the oven and before the stripping. Use of fans is best
   - is the oven band dirty? If so clean it
   - try increasing the first zone bottom temperature
   - try very lightly greasing or greasing and flouring the oven band. The greasing can be with a vegetable oil or beeswax.

7 The coloration around the biscuits is not even.
   - check the placing of the biscuits on the oven band. Spacing should be the same in all directions
   - check the even application of surface wash on the dough pieces, if applicable.
8 The biscuits are sinking into the oven wire.
   - check the biscuit weight and request correction if possible
   - increase the bottom temperature of the first zone of the oven
   - try increasing the final stage of the dough to toughen it slightly
   - try using a drier dough
   - try to use a sugar with larger particle size in the mixing.

9 Biscuit cooling and handling

9.1 Why cool biscuits?

After baking most biscuits are sent straight to be packaged. This is not only to collect them into practical sized groups for sale, but also to protect them from moisture uptake from the atmosphere, dirt and damage. It has been usual to cool the biscuits before packaging. Some cooling is, of course, inevitable, but cooling is necessary if they are to be transferred manually to wrapping machines, tins, trays or boxes. Cooling is also necessary for sugar rich biscuits since these are very soft and plastic as they leave the oven and only set rigid when cool. There is also a small loss of moisture as the biscuits cool which is beneficial to their quality and shelf life. If however the period of cooling is excessive, when the biscuits reach ambient temperatures they will start to absorb moisture from the atmosphere on all but the driest of days.

Biscuit manufacture has been mechanised to an extensive degree and in most factories there is little labour used in handling biscuits except for feeding the wrapping machines or other packaging systems. In recent years much attention has been given to the automatic handling of biscuits so that little labour may now be needed even at the packaging machine. This has made it possible to consider reducing the amount of biscuit cooling as the sensitivity of human hands may not now be the limiting factor. In most factories biscuits are not packed hot and it is, therefore, important to consider the conditions for cooling and the difficulties that may arise.

Certain groups of biscuits are prone to spontaneous breakage at variable times (up to 24 h) after cooling and packaging. This is known as 'checking' and the problem has been described in Section 6.5. Checking can be reduced or eliminated if the baking is slow and cooling gradual. The use of a post-oven dielectric drier (see Section 7.2) by applying heat preferentially to the wettest parts of the biscuit can effectively eliminate checking irrespective of the subsequent

cooling arrangements and for this reason, as well as others, dielectric (radio frequency) units are extremely useful.

On plants without dielectric driers, biscuits which are prone to checking should be cooled slowly, avoiding, in particular, cold draughts.

Cooling of biscuits, after the product is transferred from the oven band, may be by various techniques. The most common method is to carry the biscuits flat on fabric conveyors for a period of between 0.5–1.5 times the baking time. No forced convection is applied and, in fact, draughts from windows and doors should be avoided. Cooling is gradual and there is a small loss of moisture from the biscuits. By the time the biscuit reaches the end of the cooling conveyor(s) it is handhold-hot or less. If checking is a problem under these conditions, it may be useful to box in the conveyors and perhaps to stack the biscuits while they cool. Under these conditions the air around the biscuits is very warm and the relative humidity is elevated by the natural moisture loss from the biscuits. Biscuit drying is reduced but some equilibration of moisture within each biscuit takes place before the structure is truly rigid.

Cooling may also be arranged with the biscuits stacked on edge on open mesh conveyors with air blown through the mesh and biscuits. This is potentially a bad arrangement for cooling because the edges will cool quickly and moisture in the biscuit centres cannot leave as readily as when cooling in flat conditions. Blowing cold air will be particularly detrimental.

Thus when handling biscuits after leaving the oven, thought must be given not only to the heat that will be lost but also to the movement of moisture away from and into the surfaces and also internally within the biscuit.

Various conveyors and devices are used to handle and to carry baked biscuits. It is useful to define the names commonly used for the different pieces of equipment. Figure 18 should aid in understanding the relative positions and alternatives. To clarify these descriptions it is also worth redefining the meanings of 'row' and 'lane' used for lines of biscuits. A row is a line across (at 90°) to the direction of travel of the plant, and a lane is a line in the direction of production. Thus, a row is only as wide as the plant, but a lane is of infinite length.

The cooling conveyors are usually designed to run slightly faster than the oven band to allow good separation of the rows of biscuits. By using radial bends and various turnover devices they can be used

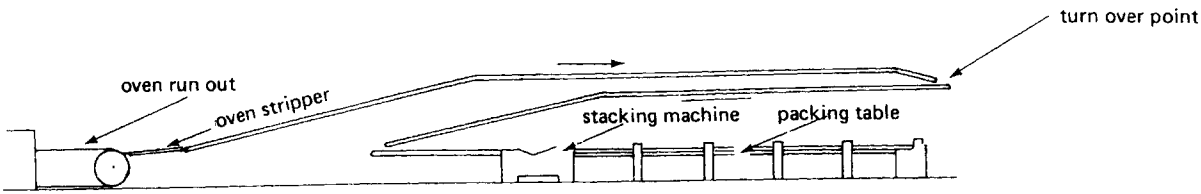


Fig. 18 Typical two tier biscuit cooler.

to take the biscuits wherever needed within the factory. It is helpful to have at least one transfer point in the conveyor system to turn the biscuits over so that the biscuit bases can be cooled.

Subsequent biscuit handling is improved if the ordered regimentation of the biscuits, which is present on the oven band, is maintained as nearly as possible throughout cooling. Thus, transfers at the oven stripper and at other places during cooling, should be designed to keep the lanes and rows straight.

9.2 Biscuit stacking and lane control

At the end of the cooling conveyors is a stacking machine. The function of this machine is to collect biscuits from the cooling conveyor, form them into lanes and stack them on edge or overlapping each other for easier handling. The performance of the stacking machine may be improved if the spacing between rows is increased before the biscuits reach it. To effect this a stacker feed conveyor with separate drive may be used.

Stacking may be effected by different techniques, but the main types are, star wheel stacking (see Fig. 19), penny stacking (Fig. 20) and flip stacking (Fig. 21).

The mechanism of the first two should be clear from the diagrams. The flip stacker relies on acceleration by a fast rotating flipping roller which throws each biscuit forward over the one before it. It may be necessary, as shown in the diagram, to have a trailing chain or web to control the flight of the biscuits. The flip stacker can stack at very high speeds and is superior in this respect to the other

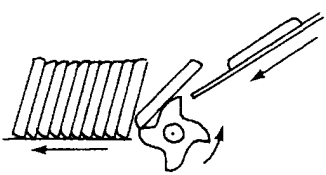


Fig. 19 Principle of the star wheel stacker.

Fig. 20 Principle of the penny stacker.

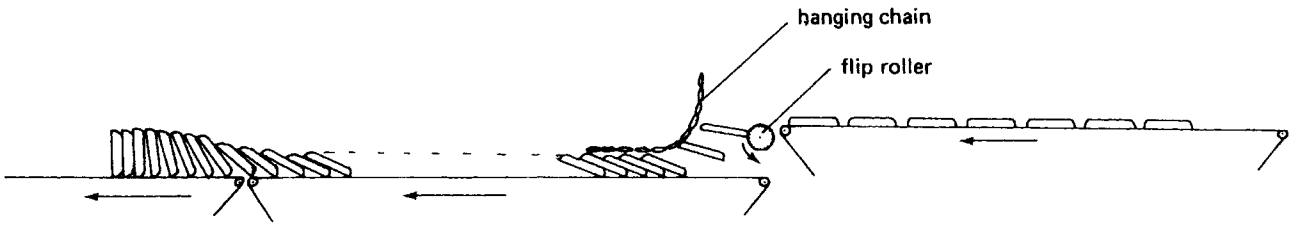


Fig. 21 Principle of the flip stacker and vertical stacking.

types. The star wheel stacker allows a more vertical orientation of the biscuits, but this orientation is possible from the other types if there is a transfer to a slower moving vertical stacking band (see Fig. 21) or if the stacking is done onto vibrating inclined conveyors.

Vibratory conveyors have become a popular and useful means of stacking and feeding biscuits to the in-feeds of wrapping machines. These U-shaped single lane conveyors are gently sloping and biscuits fed onto them are both transported and, as they bunch up, are stacked. The added advantage is that they can form a buffer storage because the bunched biscuits occupy much less room than those being transported flat.

The stacking machine usually stacks the biscuits directly onto the packing table. The height of this conveyor is adjusted to suit operators sitting or standing by it while they transfer the biscuits to wrapping machines, individual packets or into tins or trays. Guide strips of steel are usually fitted at appropriate intervals across the packing table to collect the lanes from the stacker and to maintain them along the packing table.

If the wrapping machines, creaming machines, etc. are fed automatically, the packing table also provides a reservoir should there be breaks in the running of either the production plant or the wrapping machines. Recycled biscuits can also be introduced to the system on this packing table. The recycled biscuits may result from opened defective or lightweight packs, or from trayed up product collected at some previous time when the wrapping machine was stopped, etc. Biscuits which for one reason or another are not packaged or trayed up will fall off the end of the packing table and should be collected in suitable containers. In an efficient operation, only unpackable product should be allowed to reach the end of the packing table.

It may be expedient to change the number of lanes of biscuits resulting from the cutter to suit the wrapping machine feeders, the number of operators employed or to mix the biscuits from different rows in the interest of more uniform pack weights. Many devices have been designed to lane reduce, lane distribute and lane multiply. For the most part they are simple deflector devices which aim to push the biscuits sideways without arresting their forward movement. It has been possible to introduce some electronic sensing and servo operations to compensate for lane wander as a result of band tracking, etc. By using relatively inexpensive microelectronic devices, much more sophistication can now be used. This includes:

1 programming wrapping machines,
2 feeders to collect biscuits from across the lanes to balance weights and variable supply in different lanes,
3 adjustment of lane reducers to suit groups of wrapping machines working in parallel but with any individual machines being stopped on a random basis,
4 arranging logical plant shut down, and
5 deflection of product, should hold ups occur in the wrapping area.

Alarms can be arranged to call staff for manual assistance should the automatic arrangements reach saturation point. By these means the amount of labour needed in the wrapping area can be considerably reduced making big improvements to the plant efficiencies.

9.2.1 Process control considerations

All aspects of biscuit handling and cooling are more efficient if the biscuit shape is constant. As we have seen before, this is achieved by attention to detail right through the process. As the handling and wrapping machine feeding arrangements become more automatic, there is progressively less tolerance to biscuit dimensional variation. More surveillance is needed at the oven exit to ensure that bad product does not pass forward or that trends towards out-of-standard dimensions are detected in time for corrective action to be taken. Traying up and feeding back of product becomes disproportionately labour intensive.

Only the main features of biscuit handling techniques and possibilities have been outlined. Many ingenious and special systems have been designed, including the use of air jets, air beds and vibrator arrangements to move the biscuits to predetermined positions. Although the cheapest way in most cases, gravity is not a very reliable method. Falling biscuits can easily be deflected or retarded by air currents, and friction alters with the humidity of the day or the cleanliness of the conveyor. When biscuits are passing at very high speeds and very close together the movement of each one must be identical if uniform performance with no jam-ups is to be achieved.

10.1 Care

The equipment in the baking and cooling areas involves the ovens and many fabric conveyors. It is of great importance that constant vigilance is maintained on the tracking of all the conveyors, as a conveyor that runs off the edge of its track is quickly damaged. Replacing a conveyor is usually expensive and results in much production downtime.

The oven band and certain other parts of the oven are very hot. Take care not to burn yourself and take particular care if reaching into the oven through an inspection door. As you open the inspection door steam and hot oven gases may spill out and these can be dangerous.

10.1.1 Consideration of others

- Biscuits spilled or dropped onto the floor should be cleaned up immediately because fatty material under foot can be a hazard to you and other workers.
- If you have to work at a high level to adjust or clear conveyors, take particular care not to drop or spill anything on someone who may be standing or working below you.
- If you see a fellow worker in a dangerous situation give a warning. If someone is in trouble or struggling to handle something give a hand.

10.1.2 Consideration of equipment

- Ovens should be ignited and started only in the prescribed manner. There should be safety systems to prevent explosions but if not, ignition in the correct way should prevent any dangerous or expensive incidents.

- The oven band cleaning equipment normally consists of rotating wire brushes. These should be set with care as too much pressure on the band will cause wear and may damage the smooth surface which is important for maintaining good release of the biscuits after baking.
- The material cleaned off the oven band will need to be removed at least once per shift.
- Attention to the tracking of oven bands and cooling conveyors is the most important aspect of equipment care required of the baker.
- Tracking will become a problem if the supporting rollers are not kept clean. Catch trays positioned at intervals along the conveyors should also be emptied regularly.
- At the end of a production period when the oven is about to be stopped it is essential that a running period after the burners have been switched off is maintained since overheating a band by stopping it in the oven while it is too hot may cause distortion and lead to tracking problems in the future.

10.1.3 Consideration of possible contamination of biscuits

- As biscuits leave the oven they are more or less sterile and ready for eating. Only clean hands should handle biscuits. Hands must be washed after using the toilet and washed if they become dirty with oil and grease or floor dirt. All who touch biscuits before they are wrapped must be thoughtful and vigilant about hygiene.
- Biscuits which fall to the floor must be placed in containers that ensure that they are never offered for human consumption. This includes biscuits that are sold as substandard or 'broken' or are returned to the mixing room for recycling by incorporation in dough or biscuit cream.
- If there is a system for recycling substandard biscuits great care must also be exercised to separate burnt product.
- Fabric conveyors when not in use are a favourite place for placing tools and other items. This is to be strenuously condemned as tools are dirty and possibly oily. It is very difficult to clean fabric conveyors.
- Insect and rodent infestation is a particularly serious source of contamination especially where pieces of biscuit are left around. Precautions should be in place to reduce the chance of insects, birds and animals entering a food factory but if they are seen the

matter must be reported to those responsible for controlling pests and cleaning.

10.2 Cleaning and maintenance of baking and cooling machinery

- Cleaning of this equipment is not an onerous task. Emptying catch trays and sweeping under machines is a regular task. Cleaning of the areas under ovens and particularly pits if the oven drums are sited in pits are particularly important as they harbour both insects and rodents.
- The knife or other device used to strip biscuits from the oven band becomes worn in time and must be replaced. The baker should check this at the end of each production run and report to obtain engineering maintenance if necessary
- Look for leaks of gas, fuel oil, grease or dust. Report precisely and record the problems.
- Your vigilance could ease your job and those of your colleagues. It could also save much expense, inefficiency and frustration.

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